



**COMILLAS**  
UNIVERSIDAD PONTIFICIA

**ICAI**

**INDUSTRIAL ENGINEERING MASTER**

FINAL MASTER THESIS

**DEFINITION AND IMPLEMENTATION  
OF AN ENERGY MANAGEMENT  
SYSTEM IN A PHARMACEUTICAL  
MANUFACTURING SITE**

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Madrid

July 2019



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Fecha: 20/06/2019

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# **DEFINICIÓN E IMPLANTACIÓN DE UN SISTEMA DE GESTIÓN DE ENERGÍA EN UNA PLANTA FARMACEÚTICA**

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## **RESUMEN DEL PROYECTO**

### **Introducción**

La energía es uno de los elementos clave para cualquier empresa independientemente del sector en el que desarrolle su actividad, pues suele ser una de las grandes partidas de coste. Concretamente, la industria farmacéutica es uno de los sectores más intensivos en términos de consumo de energía. Sin embargo, a menudo, los principales consumos de energía no se deben directamente a la transformación del producto, sino a la creación de las condiciones necesarias para su fabricación. En este sentido, la industria farmacéutica es una de las áreas que presenta mayores potenciales de mejora.

El precio de la energía es un factor que no se puede controlar. Sin embargo, sí se pueden tratar de contener los consumos y utilizar los recursos disponibles de la manera más eficiente posible. Estos excesos energéticos no sólo suponen un mayor coste económico debido a la energía, sino que además incrementa el desgaste de los equipos y el grado de mantenimiento que se debe aplicar a ellos.

Desde los gobiernos y las entidades oficiales, se está alentando a los consumidores a tener un mayor control sobre la energía que se consume. Es por eso por lo que se están tomando diferentes acciones y planes para promover un comportamiento más ambiental. Además, las políticas están intensificando sus objetivos de ahorro incluyendo condiciones de operación más restrictivas. Por tanto, para tratar de cumplir con la legislación energética, algunas empresas están tratando de obtener la certificación ISO 50001 y para esto, se debe establecer un Sistema de Gestión de Energía.

Un Sistema de Gestión de Energía (SGE) es un programa que engloba un conjunto de acciones y procesos que permiten a una empresa reducir sus impactos ambientales y aumentar su eficiencia para lograr mejoras económicas, ambientales y operativas de manera continua.

Ante estas medidas y requerimientos, surge este proyecto. En este momento, la planta farmacéutica de estudio no cuenta con un sistema adecuado de gestión de la energía. Únicamente tiene unas hojas de cálculo que se utilizan para controlar el consumo de energía de la planta, pero estos son demasiado generales por lo que resultan difíciles de analizar y, por tanto, de identificar dónde llevar a cabo los ahorros y mejora continua. Además, aunque en años anteriores ya se llevaron a cabo medidas y acciones (cambio de luminarias, variadores de frecuencia o baterías de condensadores, por ejemplo) para mejorar la eficiencia de la planta, este proceso se debe actualizar de manera continua.

## **Metodología**

Por tanto, este proyecto tiene como objetivo principal la definición e implementación de un sistema de gestión energética en una planta farmacéutica. A través de este sistema se tratará de impulsar la eficiencia energética gracias a la monitorización de los consumos de energía. Concretamente para este proyecto, debido a la novedad y limitación de tiempo, se tratará únicamente la electricidad, aunque en fases posteriores se incluirán otras energías.

Así, como punto de partida, se deberá instalar el equipo de monitorización. Para ello, es necesario profundizar el conocimiento sobre la planta farmacéutica. Será necesario conocer los procesos que tienen lugar, los equipos y la instalación en general, las condiciones de operación e información general sobre los consumos disponibles.

A partir de este primer análisis de la situación actual de la planta se decidirá dónde y qué equipo de monitorización instalar. Los dispositivos medirán los consumos y enviarán la información recogida a una base de datos a la que será posible acceder desde cualquier dispositivo a través de un software de la empresa alemana deZem, que no requiere de instalación pues está basado en la nube.

Una vez dicho sistema esté en marcha, se procederá al análisis de consumos. Se tratará de identificar líneas base, consumos medios y patrones de consumo, así como ineficiencias y fallos que permitan mejoras en la eficiencia de la planta. Este estudio permitirá tener una primera aproximación de la distribución de energías.

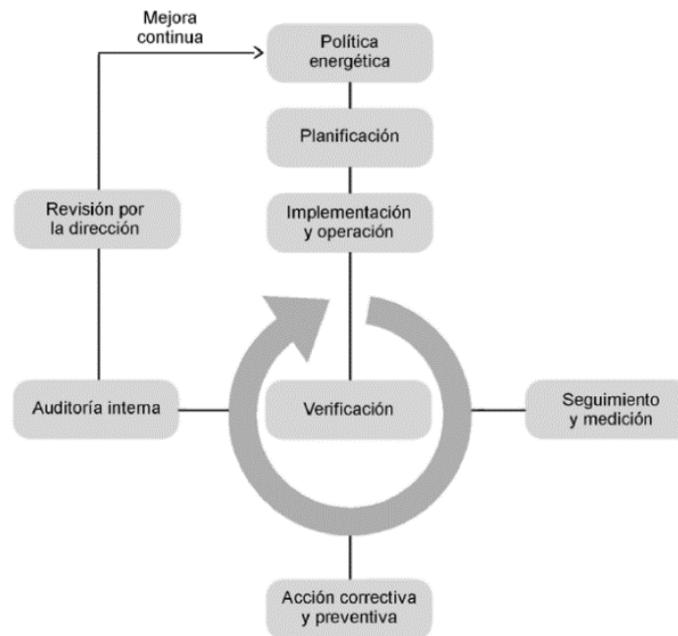
Mediante el análisis y seguimiento de consumos a tiempo real se propondrán una serie de medidas y acciones encaminadas a la reducción de consumos y, por consiguiente, a un ahorro económico en la planta. Además, se hará una pequeña estimación del ahorro que supondría llevar a cabo dichas acciones en la planta de estudio.

Paralelamente, será necesario comprender en qué consiste un sistema de gestión de energía y familiarizarse con la norma ISO 50001: 2018 para poder desarrollar el proyecto de acuerdo con sus requisitos. El propósito de este reglamento es facilitar el establecimiento e implementación de sistemas y acciones de la organización que ayuden a mejorar su rendimiento energético de manera continua. Este trabajo incluirá los procedimientos generales y específicos del Sistema de Gestión de Energía y sus registros asociados para la implantación y desarrollo del sistema.

## **Resultados**

Para poder implementar el Sistema, en primer lugar, se estudió la ISO 50001. Dicho estándar, proporciona un marco para el desarrollo del SGE en las organizaciones. Esta norma se ocupa principalmente del uso y consumo de energía, la medición y el monitoreo del consumo, y el desarrollo e implementación de un plan de gestión para mejorar el rendimiento energético de la organización. En consecuencia, el propósito de la norma es llevar a las organizaciones a reducir su consumo de energía.

Este estándar está basado en el ciclo de Deming de planificar, hacer, comprobar y actuar. A lo largo del proyecto, se han establecido los pasos y formularios a complementar en cada una de las fases. Este proceso de mejora continua se puede resumir en el siguiente gráfico:



**Ilustración 1.** Proceso de mejora continua de la ISO 50001

Una vez se asentaron las bases para la futura certificación, se implementó el sistema de monitorización. Un sistema de monitorización está formado por un equipo de monitorización, un colector de datos, un sistema de comunicación y el software de análisis. Inicialmente, sólo se especificaba el software a utilizar, el resto de los elementos estaban por decidir. Tras un estudio de mercado, se llegó a la conclusión que, para lograr la mayor estandarización y menor gasto, la mejor solución era la de utilizar el equipo de la propia empresa del software: deZem.

Por tanto, tras el análisis inicial de la planta, se decidieron monitorizar 18 circuitos desde el Cuadro General de Baja Tensión (CGBT). Concretamente, se controlaron los siguientes:

**Tabla 1.** Circuitos monitorizados

1	Planta Técnica	10	Trafo 2
2	Enfriadora 1	11	Edificio social
3	Enfriadora 2	12	Edificio oficinas ala oeste
4	Enfriadora 3	13	Almacén
5	Módulo exterior I+D	14	Pesadas y sólidos
6	Líquidos	15	Acondicionamiento
7	Semisólidos y cápsulas	16	Aire comprimido
8	Alumbrado	17	Climatización SM
9	Trafo 1	18	Emergencia

Para cada uno de estos circuitos, se eligieron tres periodos de tiempo con el fin de identificar patrones de consumo, líneas base y consumos medios. Concretamente se escogieron: una semana con días festivos, pero sin cuarto turno (no se trabajó el fin de semana), otra semana con días festivos pero con cuarto turno, y otro periodo de dos semanas de funcionamiento normal.

Se observó que los analizadores instalados suponían la monitorización del 71% de la planta tal y como se presenta a continuación:

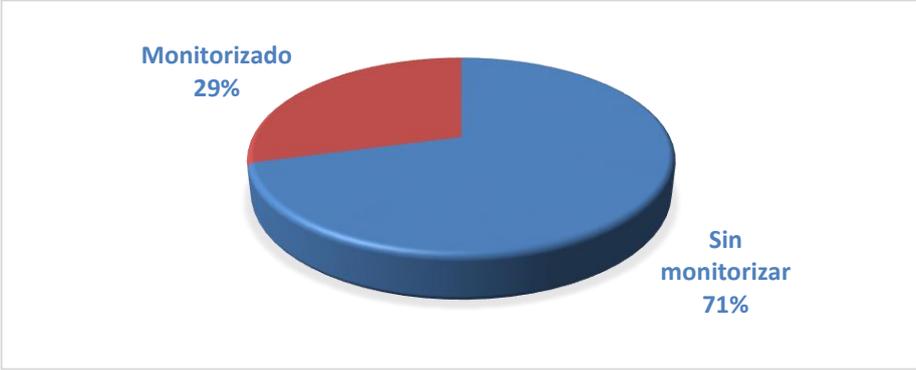


Ilustración 2. Consumos de la planta monitorizados

De hecho, de este 71% monitorizado, el consumo de electricidad de la planta se distribuye de la siguiente manera:

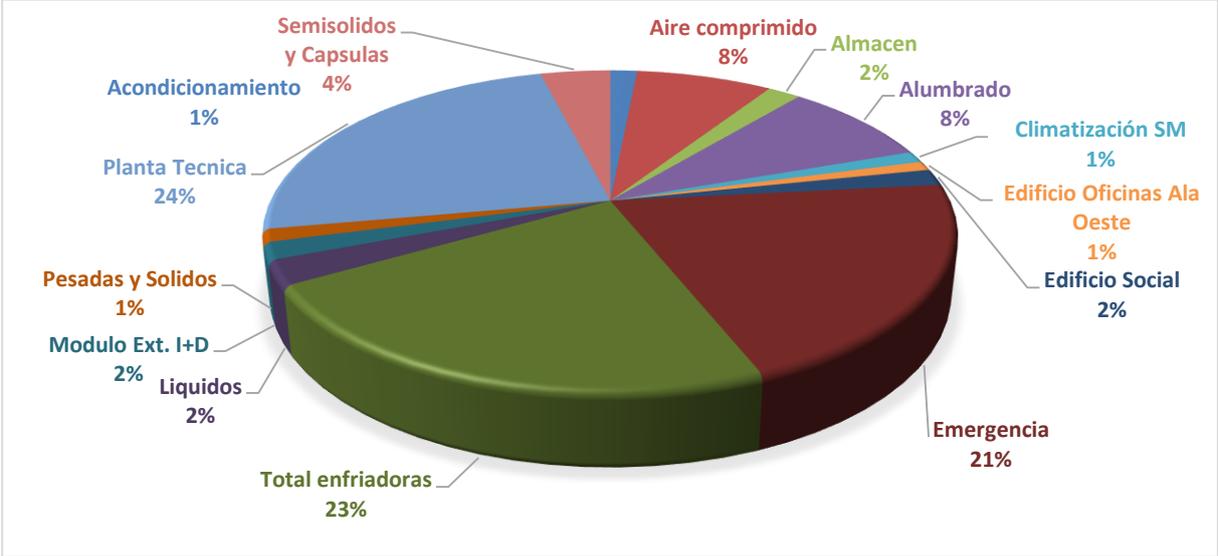
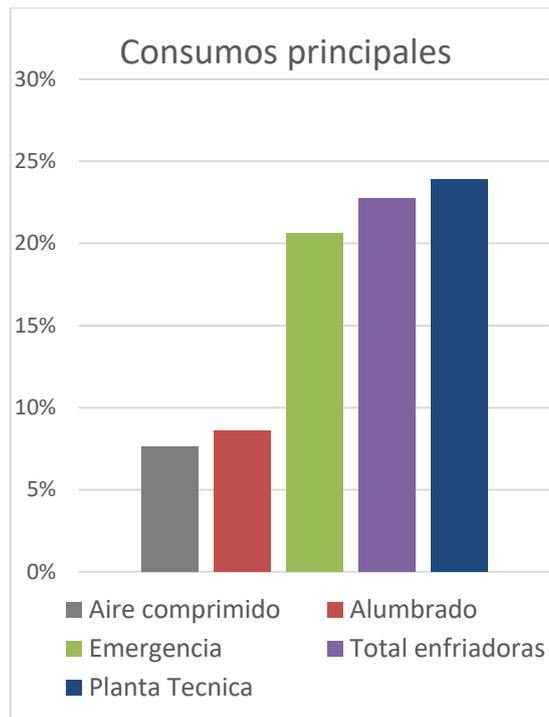


Ilustración 3. Distribución de la energía consumida en la planta

Por tanto, se ve claro que los principales consumos de la planta son los de los circuitos de Aire Comprimido, Alumbrado, Emergencia, Enfriadoras y Planta Técnica. A continuación, se muestra un gráfico de Pareto con dichos consumos:



**Ilustración 4.** Principales consumos de la planta farmacéutica

Los resultados mostraron que no son las máquinas las que suponen un mayor consumo en la planta sino la climatización. Esta supone prácticamente el 65% del consumo total monitorizado actual. Además, el consumo que más varía es el de las Enfriadoras pues depende de las necesidades de la planta.

Por lo tanto, al realizar un análisis en mayor profundidad, estas áreas deberían ser las primeras en ser estudiadas porque son en las que se pueden generar mayores ahorros para la planta. En particular, las que son más atractivas para implementar medidas son los circuitos de Aire Comprimido, Alumbrado y Enfriadoras. El circuito de Emergencia no se consideró pues el consumo no varía excesivamente y es necesario suministrar electricidad a los equipos críticos que tiran de dicho circuito. Tampoco se tuvo en cuenta la Planta Técnica ya que esa parte de la planta estaba en proceso de cambios. Por lo tanto, el estudio se ha centrado en los otros consumos.

Para cada una de estas áreas, se estudiaron posibles medidas o acciones que llevar a cabo para tratar de reducir sus consumos. Así, por ejemplo, para el aire comprimido se podría inspeccionar cada equipo en busca de fugas o ramales sin utilizar, se podría comprobar que el aire sea lo más frío posible, así como la presión de generación. Para las enfriadoras, se debería estudiar en profundidad su operabilidad pues en el análisis se observó que, en algunos momentos, las tres máquinas funcionan a la vez, cuando todavía alguna de ellas tiene capacidad para dar más, generando así ineficiencias. Por último, para el alumbrado, se podrían cambiar luminarias, hacer un mejor uso de la luz natural o instalar sensores. Pero, sobre todo, lo primero que se debe hacer es fomentar y concienciar al personal de la planta para que apaguen luces y máquinas que no se utilicen.

## Conclusiones

Los requisitos que impone el propio mercado hacen que la gestión ambiental en general, y la energía en particular, sean piezas clave para el desarrollo estratégico de las empresas. Para intentar hacer un uso más eficiente de la energía y, sobre todo, para reducir los costos, la planta de estudio farmacéutica ha decidido implementar un sistema de gestión de energía.

Este proyecto tenía dos objetivos fundamentales: definir el sistema de gestión que la planta utilizará para la certificación de la norma ISO 50001 y para ello era necesario contar con un sistema de monitoreo del consumo.

Respecto al sistema de monitoreo es necesario resaltar varios puntos. En primer lugar, el análisis previo para la selección del equipo ha resultado ser un proceso difícil debido a la no actualización o no existencia de cierta información. Además, la solicitud, recepción y puesta en marcha de este sistema tardó más de lo esperado. De hecho, la instalación no se realizó correctamente al principio, pues dos de los equipos venían mal configurados de fábrica, por lo que identificar y corregir el problema llevó algunas semanas.

Sin embargo, una vez estuvo en marcha, el análisis y seguimientos de consumos resultó ser sencillo e intuitivo. De acuerdo con el análisis realizado, los principales consumos de la planta son los de Alumbrado, Aire Comprimido, Emergencia, Planta Técnica y Enfriadoras. Especialmente el consumo de estos tres últimos. Sin embargo, los que presentaban mayor potencial eran Alumbrado, Aire Comprimido y Enfriadoras.

Para tratar de reducir estos, se han propuesto una serie de medidas. Aunque lo primero que debería hacer la empresa, sería hacer un estudio en profundidad de las máquinas y los procesos para encontrar fugas o ineficiencias de operación. Además, aumentar la conciencia de la importancia del ahorro de energía para el personal de la planta. Con estas medidas, ya deberían ver los ahorros.

Por último, se ha estudiado el coste total de implementar este sistema y se realizó una estimación del ahorro que supondría llevar a cabo una reducción de los consumos principales. Se ha estimado un porcentaje realista y viable. Suponiendo ahorros en Alumbrado, Aire comprimido y Enfriadoras, solo en el primer año se ahorraron 23.000 €.

Paralelamente a esta implementación, se han establecido los pasos que la empresa debe seguir para obtener la certificación de la ISO 50001. Está claro que este proyecto es solo la fase inicial de un proceso largo y continuo que la planta farmacéutica debe llevar a cabo para tratar de funcionar de la manera más eficiente posible.

Como pasos futuros a seguir se proponen, en primer lugar, lograr la monitorización del 100% de consumos de la planta. Además, estudiar qué otras variables aparte de la potencia activa serían interesantes para visualizar en el software. Por otro lado, realizar un análisis y estudio en profundidad de los equipos y procesos que requieren de cada una de las áreas controladas. Los expertos en máquinas y procesos deben llevarlo a cabo, ya que son los que conocen y controlan el rendimiento y funcionamiento regular de los mismos. Así se podrán buscar medidas

específicas que apliquen y mejoren la eficiencia de la planta e impliquen ahorros en términos de costo. También, expandir el proyecto a aire comprimido, gas, agua y otras fuentes de energía. Por último, obtener la certificación de la ISO 50001.

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# **DEFINITION AND IMPLEMENTATION OF AN ENERGY MANAGEMENT SYSTEM IN A PHARMACEUTICAL MANUFACTURING SITE**

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Director: Moreno García, Tomás

## **PROJEC SUMMARY**

### **Introduction**

Energy is one of the key elements for any company regardless of the sector in which it develops its activity, since it is usually one of the major cost items. Specifically, the pharmaceutical industry is one of the most intensive sectors in terms of energy consumption. However, often, the main energy consumption is not directly due to the transformation of the product, but to the creation of the necessary conditions for its manufacture. In this sense, the pharmaceutical industry is one of the areas with the greatest potential for improvement.

The price of energy is a factor that cannot be controlled. However, we can try to contain the consumption and use the available resources in the most efficient way possible. These energy surpluses not only mean a higher economic cost due to energy, but it also increases the wear of the equipment and the degree of maintenance that must be applied to them.

From governments and official entities, consumers are being encouraged to have more control over the energy that is consumed. That is why they are taking different actions and plans to promote more environmental behavior. In addition, the policies are intensifying their savings targets including more restrictive operating conditions. Therefore, to try to comply with the energy legislation, some companies are trying to obtain ISO 50001 certification and for this, an Energy Management System must be established.

An Energy Management System (EMS) is a program that encompasses a set of actions and processes that allow a company to reduce its environmental impacts and increase its efficiency to achieve economic, environmental and operational improvements on an ongoing basis.

After these measures and requirements, this project arises. Currently, the study pharmaceutical plant does not have an adequate energy management system. It only has spreadsheets that are used to control the energy consumption of the plant, but these are too general, so they are difficult to analyze and, therefore, to identify where to carry out the savings and continuous improvement. In addition, although in previous years measures and actions were already carried out (changing luminaires, frequency inverters or capacitor banks, for example) to improve the efficiency of the plant, this process must be updated continuously.

## **Methodology**

Therefore, this project has as main objective the definition and implementation of an energy management system in a pharmaceutical plant. Through this system we will try to boost energy efficiency thanks to the monitoring of energy consumption. Specifically, for this project, due to the novelty and time limitation, electricity will be treated only, although in later phases other energies will be included.

Hence, as a starting point, the monitoring equipment must be installed. For this, it is necessary to deepen the knowledge about the pharmaceutical plant. It will be necessary to know the processes that take place, the equipment and the installation in general, the operating conditions and general information on the available consumptions.

From this first analysis of the current situation of the plant, it will be decided where and what monitoring equipment to install. The devices will measure the consumption and send the information collected to a database that can be accessed from any device through a software of the German company deZem, which does not require installation because it is based on the cloud.

Once the system is properly working, the consumption analysis will proceed. The baselines, average consumption and consumption patterns, as well as inefficiencies and failures that allow improvements in the efficiency of the plant will try to be identified. This study will allow to have a first approximation of the distribution of energies.

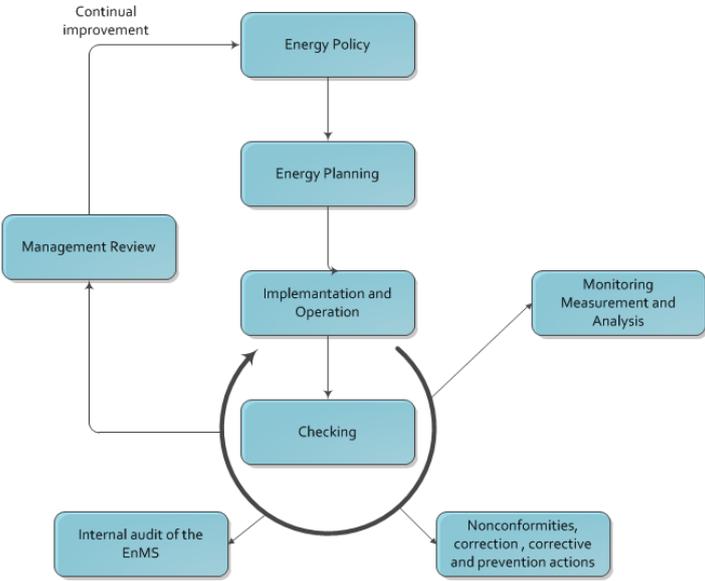
Through the analysis and monitoring of real-time consumption, a series of measures and actions aimed at reducing consumption and, consequently, at an economic saving in the plant, will be proposed. In addition, a small estimation of the savings that would imply to carry out these actions in the study plant will be made.

At the same time, it will be necessary to understand what an energy management system consists of and become familiar with ISO 50001: 2018 in order to be able to develop the project in accordance with its requirements. The purpose of this regulation is to facilitate the establishment and implementation of systems and actions of the organization that help to improve their energy performance continuously. This work will include the general and specific procedures of the Energy Management System and its associated registers for the implementation and development of the system.

## **Results**

In order to implement the System, first, ISO 50001 was studied. This standard provides a framework for the development of the SGE in organizations. This standard deal mainly with the use and consumption of energy, the measurement and monitoring of consumption, and the development and implementation of a management plan to improve the energy performance of the organization. Consequently, the purpose of the standard is to lead organizations to reduce their energy consumption.

This standard is based on the Deming cycle of planning, doing, checking and acting. Throughout the project, the steps and forms to be complemented in each of the phases have been established. This process of continuous improvement can be summarized in the following graph:



**Illustration 1.** Continuous improvement process of ISO 50001

Once the bases for future certification were established, the monitoring system was implemented. A monitoring system consists of a monitoring equipment, a data collector, a communication system and the analysis software. Initially, only the software to be used was specified, the rest of the elements were to be decided. After a market study, it was concluded that, to achieve greater standardization and lower expenditure, the best solution was to use the equipment of the software company itself: deZem.

Therefore, after the initial analysis of the plant, it was decided to monitor 18 circuits from the Low Voltage General Switchboard (LVGS). Specifically, the following were controlled:

**Table 1.** Monitored circuits

1	Planta Técnica	10	Trafo 2
2	Enfriadora 1	11	Edificio social
3	Enfriadora 2	12	Edificio oficinas ala oeste
4	Enfriadora 3	13	Almacén
5	Módulo exterior I+D	14	Pesadas y sólidos
6	Líquidos	15	Acondicionamiento
7	Semisólidos y cápsulas	16	Aire comprimido
8	Alumbrado	17	Climatización SM
9	Trafo 1	18	Emergencia

For each of these circuits, three time periods were chosen in order to identify consumption patterns, baselines and average consumption. Specifically, they were chosen: one week with holidays, but no fourth shift (weekend was not worked), another week with holidays but with fourth shift, and another period of two weeks of normal operation.

It was observed that the installed analyzers involved the monitoring of 71% of the plant as presented below:

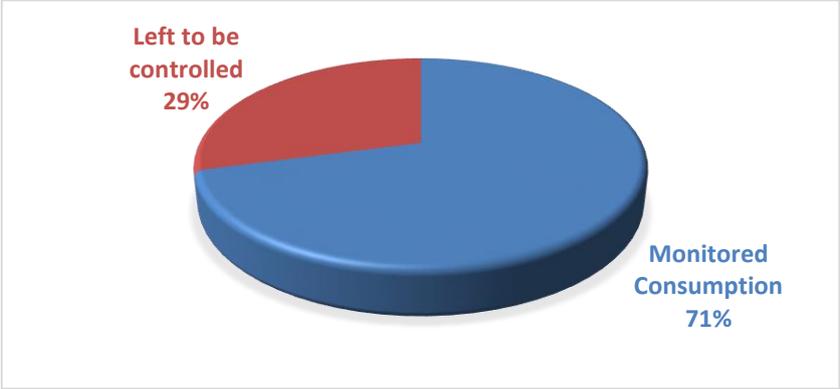


Illustration 2. Site consumption monitored

In fact, of this 71% monitored, the electricity consumption of the plant is distributed as follows:

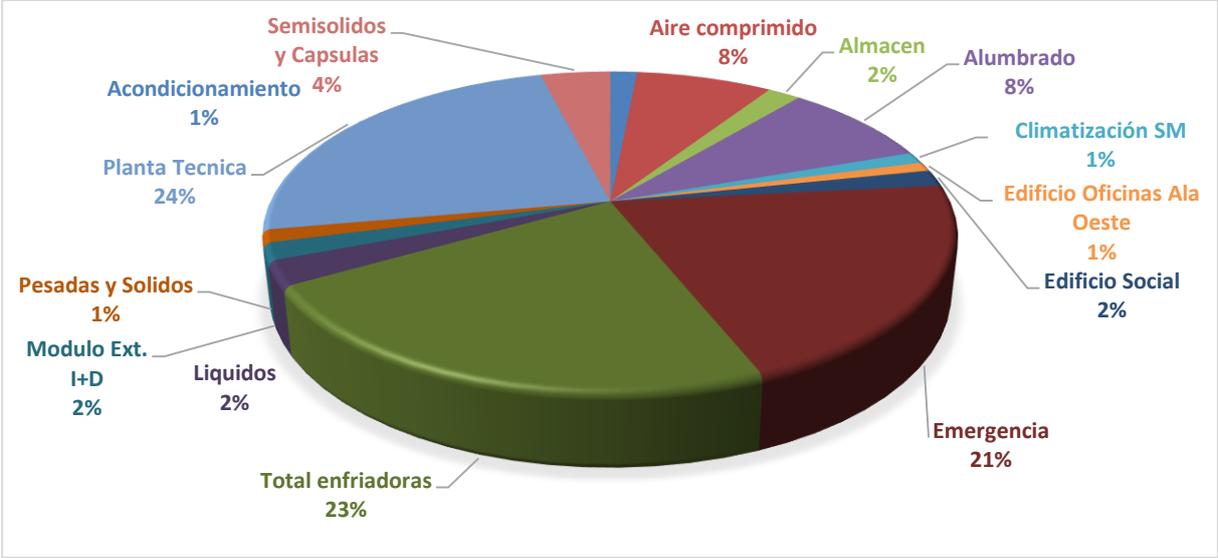
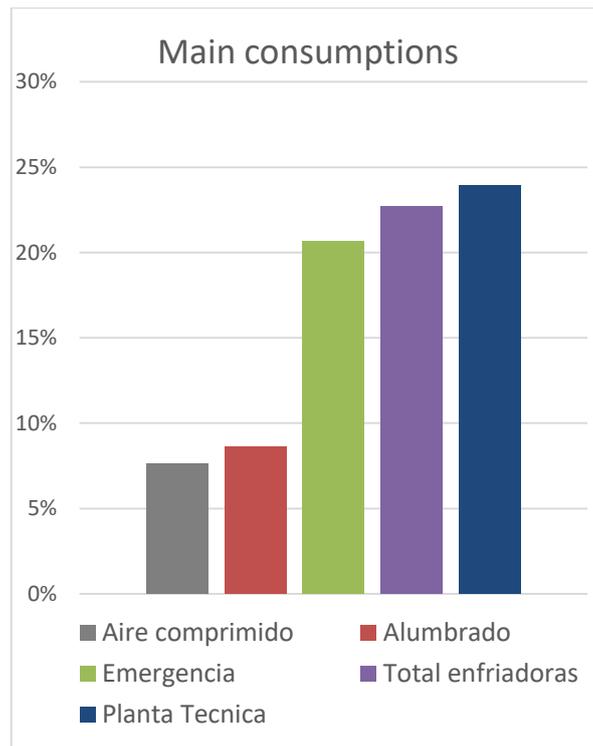


Illustration 3. Consumption distributions

Therefore, it is clear that the main consumptions of the plant are those of the circuits of Aire Comprimido, Alumbrado, Emergencia, Enfriadoras and Planta Técnica. Next, a Pareto graph with these consumptions is shown:



**Illustration 4.** Main consumptions of the site

The results showed that it is not the machines that suppose a greater consumption in the site but the air conditioning. This represents practically 65% of the current total monitored consumption. In addition, the consumption that varies the most is that of the Enfriadoras, since it depends on the needs of the plant.

Therefore, when performing an analysis in greater depth, these areas should be the first to be studied because they are where you can generate greater savings for the plant. In particular, those that are more attractive to implement measures are the Aire Comprimido, Alumbrado and Enfriadoras. The Emergencia circuit was not considered as the consumption does not vary excessively and it is necessary to supply electricity to the critical equipment that pulls the circuit. Nor was the Planta Tecnica taken into account since that part of the plant was in the process of being changed. Therefore, the study has focused on the other consumptions.

For each of these areas, possible measures or actions to be taken to try to reduce their consumption were studied. Thus, for example, for the Aire Comprimido, each unit could be inspected for leaks or unused branches, it could be checked that the air is as cold as possible, as well as the generation pressure. For Enfriadoras, it should be studied in depth its operability because in the analysis it was observed that, in some moments, the three machines work at the same time, when still some of them have the capacity to give more, thus generating inefficiencies. Finally, for Alumbrado, they could change luminaires, make better use of natural light or install sensors. But, above all, the first thing that must be done is to encourage and make staff aware of the importance of the efficiency of the plant so that they turn off lights and machines that are not used.

## Conclusions

The requirements imposed by the market itself make environmental management in general, and energy in particular, to be key pieces for the strategic development of companies. To try to make a more efficient use of energy and, above all, to reduce costs, the pharmaceutical study plant has decided to implement an energy management system.

This project had two fundamental objectives: to define the management system that the plant will use for the certification of ISO 50001 and for this it was necessary to have a consumption monitoring system.

Regarding the monitoring system it is necessary to highlight several points. In the first place, the previous analysis for the selection of the equipment has turned out to be a difficult process due to the non-updating or non-existence of certain information. In addition, the request, reception and start-up of this system took longer than expected. In fact, the installation was not carried out correctly at the beginning, as two of the computers were incorrectly configured at the factory, so it took a few weeks to identify and correct the problem.

However, once it was working, the analysis and monitoring of consumption turned out to be simple and intuitive. According to the analysis carried out, the main consumptions of the plant are those of Aire Comprimido, Alumbrado, Emergencia, Enfriadoras and Planta Tecnica. Especially the consumption of these last three. However, those with the greatest potential were Aire Comprimido, Alumbrado and Enfriadoras.

To try to reduce these, a series of measures have been proposed. Although the first thing that the company should do, it would be to do an in-depth study of the machines and the processes to find leaks or inefficiencies of operation. In addition, increase awareness of the importance of energy savings for plant personnel. With these measures, you should already see the savings.

Finally, it has been collected the general investment that a system implies and also an estimation has been made of the savings that would imply a reduction in the main consumption. A realistic and viable percentage has been estimated. Assuming savings in Aire Comprimido, Alumbrado and Enfriadoras, only in the first year they would save € 23,000.

Parallel to this implementation, the steps that the company must follow to obtain ISO 50001 certification have been established. It is clear that this project is only the initial phase of a long and continuous process that the pharmaceutical company must carry out to treat to operate in the most efficient way possible.

As future steps to be followed, it is proposed, in the first place, to achieve the monitoring of 100% of the plant's consumption. Also, study what other variables apart from the active power would be interesting to visualize in the software. On the other hand, perform an analysis and in-depth study of the equipment and processes that require each of the controlled areas. The experts in machines and processes must carry it out, since they are those that know and control the performance and regular operation of the same. Thus, specific measures that apply and improve the efficiency of the plant and imply savings in terms of cost can be sought. Also,

expand the project to compressed air, gas, water and other energy sources. Finally, obtain the ISO 50001 certification.

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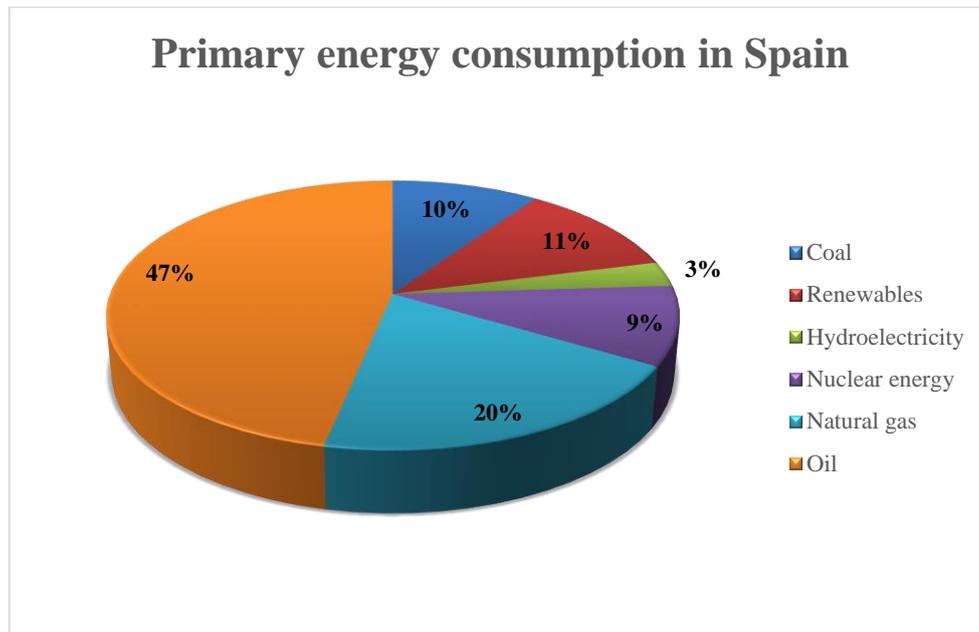
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## 1. INTRODUCTION

### 1.1. CONTEXT

Nowadays, energy represents a necessary and vital resource in any industry or sector of activity. Primary energy consumption in Spain is based mainly on fossil energy sources, especially oil, gas and coal, (BP, June 2018) as we can see in Figure 1.



**Figure 1.** Primary energy consumption in Spain in 2017

**Source:** Own elaboration with data from BP Statistical Review of World Energy 2018 (BP, June 2018)

In recent years, the increases in population and technological development have resulted in a high-energy consumption that has led to the emergence of a growing concern for energy savings and the use of renewable energy.

In order to deal with energy demand, price variability and supply disturbances, the European Union has updated its strategy. This strategy (EC, October 2014) pursues security of supply, competitiveness and sustainability. It has set as objectives:

- To reduce greenhouse gas emissions by 40% compared to 1990 levels.
- To obtain 27% of the energy from renewable sources.
- To improve energy efficiency by 27%.

This framework, adopted by the leaders of the EU in October 2014, is based on the climate and energy package until 2020.

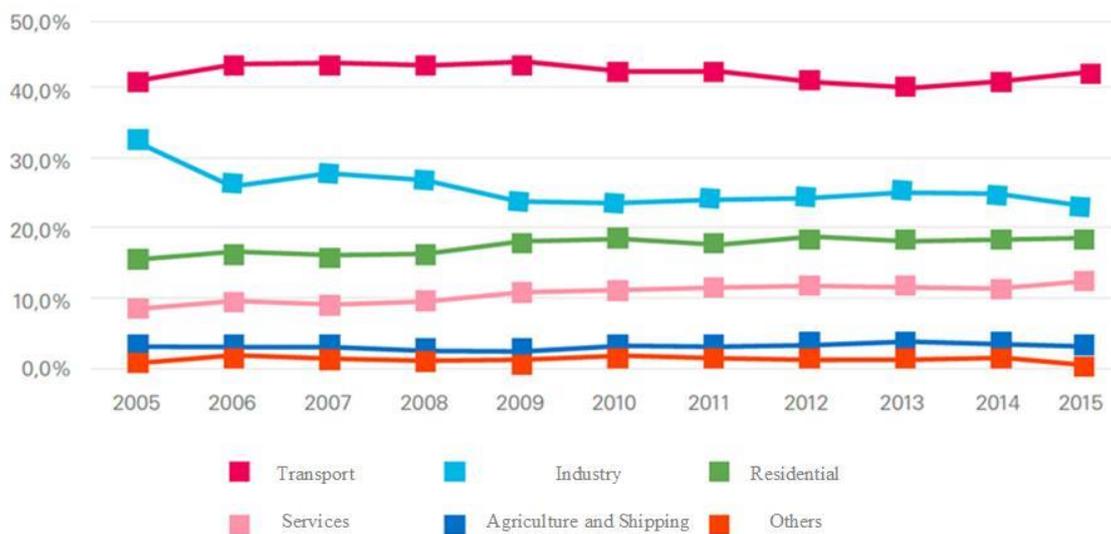
According to the Institute for Energy Diversification and Saving (IDAE), energy efficiency can be defined as "a set of programs and strategies to reduce the energy consumed by certain devices and systems without affecting the quality of energy the services provided".

The saving of energy consists therefore of reducing the consumption of primary energy in consumption centers through the implementation of the different measures. The idea is to guarantee at all times the maintenance of quality, productivity and safety, all with the least possible environmental impact (Owusu & Asumadu-Sarkodie, 2016). The aim is to reduce both energy consumption and the energy dependence of fossil fuels and their emission of gases harmful to the environment.

In Spain, there are also other regulations and plans relating (Pedrajas Boceta, June 2017) to energy saving and audits such as Royal Decree 56/2016 (Ministerio de Industria, 2016), the UNE-EN 16247 standard (UNE, 2014), the Regulation of Thermal Installations in Buildings (Presidencia, 2007) or the ISO 50001 standard (UNE-EN ISO, 2011) that will be presented later.

Therefore, it is clear that responsible consumption and efficient use of energy sources is the order of the day and is essential for the future of all inhabitants. A cultural change regarding energy behavior is necessary to promote a new energy model based on sustainable energy generation and more efficient and responsible consumption for companies.

As it is expected, consumption is linked to the activity of each company. The industry, despite having reduced its weight by 26% from 2005 to 2015, it is still one of the most intensive sectors in terms of energy consumption (ENDESA, 2017) as it can be seen in Figure 2:



**Figure 2.** Final consumer distribution per sector.

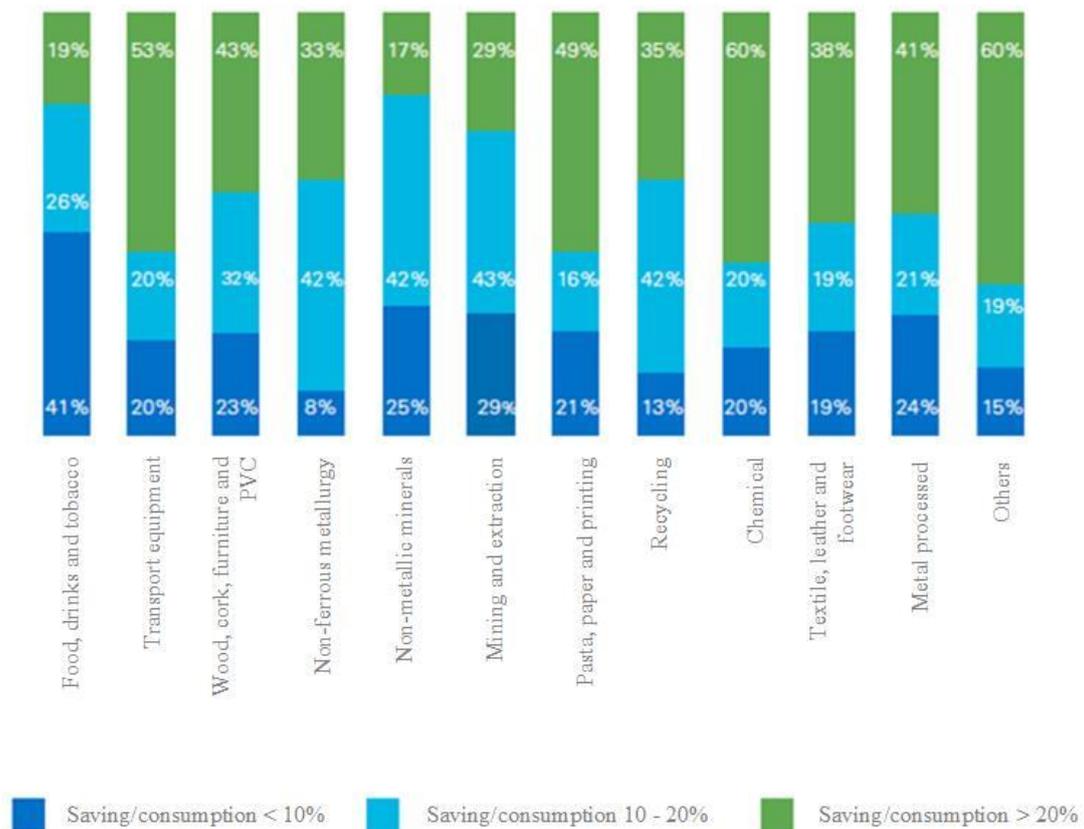
**Source:** Image taken from Endesa. Presentación Informe Comportamiento Energético 2017 (ENDESA, 2017)

The industrial sector, due to its high energy consumption and thanks to the availability of experts in the processes, has a significant degree of efficiency implemented. Yet, it should focus its efforts on improving energy contracting and the elimination of consumed ghosts. According

to the report made by ENDESA (2017), 15% of companies already have energy saving measures in place, although 51% of them could still improve their energy contracts.

By doing a deeper analysis of the situation of the subsectors, the chemical activity stands out with a high saving power among its companies. However, despite having a greater awareness about energy efficiency due to its high-energy consumption, in general, the chemical subsector still has a high potential of improvement:

- 20% of companies have a potential savings of less than 10% of their consumption energetic.
- 20% of companies could save between 10% and 20% of their consumption energetic.
- 60% of companies would have a potential savings greater than 20% of their consumption energetic.



**Figure 3.** Savings/consumption percentages in the industrial subsectors

**Source:** Image taken from Endesa. Presentación Informe Comportamiento Energético 2017 (ENDESA, 2017)

It is clear that we are on the right path towards the reduction of energy consumption. Nevertheless, there is still more to be done and both governments and the companies themselves must try to function in the most efficient way through the control of their processes and the implementation of new measures.

## 1.2. PHARMACEUTICAL INDUSTRY

The pharmaceutical industry is a business sector dedicated to the manufacture, preparation and commercialization of medicinal chemical products for the treatment and prevention of diseases. All new medicines introduced into the market are the result of lengthy, costly and risky research and development (R&D) conducted by pharmaceutical companies

Global demand for pharmaceuticals is growing continuously as the result of a growing world population and demographic change (GTAI, 2017). This fact has made that the healthcare industry becomes one of the most important global growth markets. At the end, the pharmaceutical industry is one of the most profitable and influential business sectors worldwide.

It is made up of numerous public and private organizations that are destined to the discovery, development, manufacture and commercialization. The leading pharmaceutical companies (Ellis, 2019) come from the United States and Europe. Some of the main global players from the United States are Pfizer, Johnson & Johnson, Merck & Co., and AbbVie. Novartis and Roche come from Switzerland, GlaxoSmithKline and AstraZeneca from the United Kingdom, Bayer from Germany and Sanofi from France.

At the national level, the most present companies are Gilead, Novartis, Abbvie in the hospital market or Cinfa, Sanofi-Aventis, GSK or Merck in the pharmacy market (Simón Ruiz, 2019).

The pharmaceutical industry is one of the key subsectors of the Spanish economy. One of its main drivers is the investment in R&D, which is much higher than the average for Spanish industry (R&D investment capacity is over 1,000 million euros per year).

Regarding energy consumption, the pharmaceutical sector, which in 2016 contributed 2% to the turnover of the industry in Spain, already represented 2.6% of its production back then. This sector, as some experts point out, is one of the most sensitive to the variation in energy prices, both in electricity, gas and steam. Specifically, according to the last reliable information available from 2016, the specific consumption per unit of solid product amounted to 0.4156 kWh of electricity per kg and 0.0610 kWh/kg in the case of gas. The specific consumption per unit of liquid product stood at 0.221 kWh/liter for electricity consumption and 0.198 kWh/liter for gas (Energética21, 2016).

Therefore, the pharmaceutical industry is a big consumer of energy. Its production includes several processes that consume electricity, steam, fuels, etc. However, when these industries undertake a project to optimize their energy efficiency, a dual objective is posed: the improvement of technology in equipment and industrial processes and, at the same time, the implementation of energy management systems.

Often, the main energy consumptions are not due directly to the transformation of the product, but to the creation of the necessary conditions for its manufacture. In this sense, there are usually numerous areas where there is room to improve performance and consumption management:

start-up and control of engines, pumps, ovens, burners and boilers, thermal isolation, air conditioning and lighting or auxiliary equipment (Profesionales Hoy, 2017).

Hence, it is fundamental to bet for improvement of its productive processes as well as the reduction of electrical and thermal consumption through energy efficiency. The purpose of it, is to guarantee its viability in the long term and to seek the optimization of costs that are not its core business. This way, margins may be contained.

### **1.3. COMPANY CASE STUDY: PHARMACEUTICAL PLANT**

The implementation of an energy management system project will be carried out in a pharmaceutical plant owned by an international pharmaceutical laboratory.

The main activities developed in the plant are production and research projects. In particular, they are specialized in the production of soft capsule medicines, a galenic form that accelerates the action of drugs and facilitates the administration of active ingredients that are difficult to dissolve in water. Besides, it has researchers working in the development of new products, especially in the field of vitamins, analgesics and laxatives.

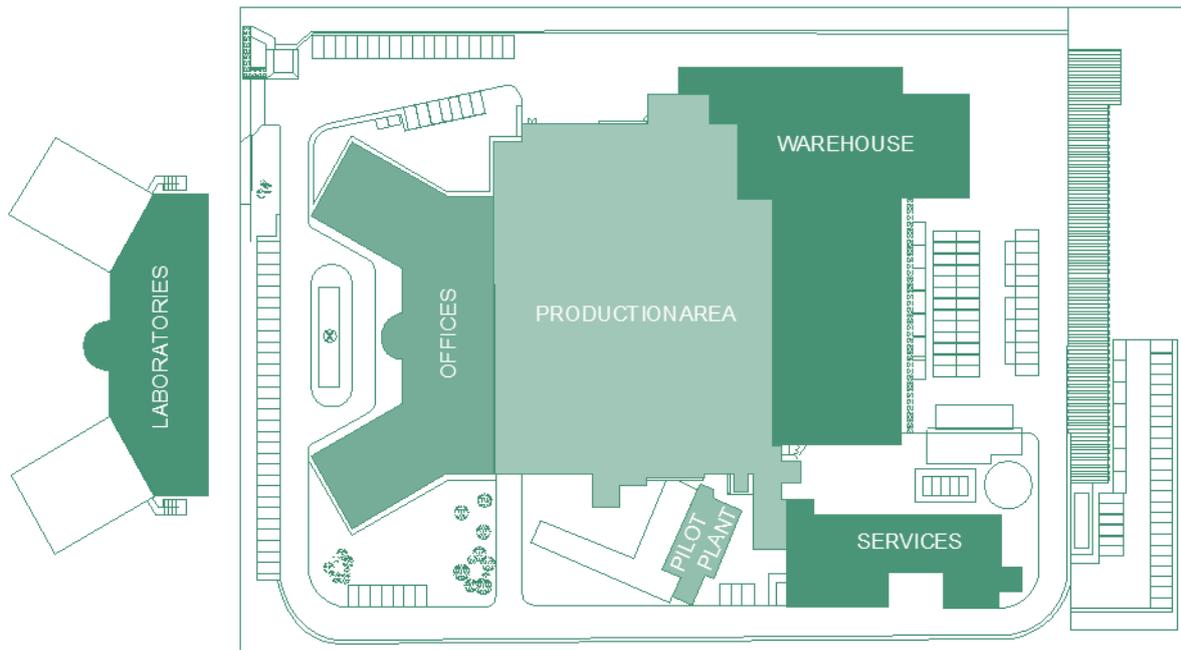
The plant has a total constructed area of 12,800 m<sup>2</sup> and has around 350 employees. It is located in Madrid.

The central location of the site enables an easy supply of raw materials and distribution of final products to their customers. It exports around 90% of its production.

The site has three linked buildings and the facilities are mainly divided in six areas that contain the production, laboratories, quality control, warehouse, administrative offices (Supply chain management; Engineering; Quality Assurance and Administration), services and areas for general use (canteen; changing rooms to access the manufacturing areas).

In the same plot there is an annex building which includes the Galenic Plant facilities of Innovation & Development Department.

All of this can be seen in Figure 4:



**Figure 4.** Site layout

#### **1.4. REGULATIONS APPLIED**

Energy efficiency consists of reducing energy consumption without reducing neither comfort nor the quality of life, ensuring the supply, protecting the environment and fostering sustainability (Santiago Fink, 2011). The process of convergence with Europe in energy matters implies the progressive adoption of a series of measures aimed at efficiency.

As part of the regulation, the organization must identify which requirements apply to its use consumption of energy and efficiency. This way, they will be able to implement and maintain the system taking into account these requirements.

Here, the regulations, promotion plans, and most relevant strategies related to energy saving and energy audits that currently exist in Spain and need to be considered are briefly discussed.

- Royal Decree 56/2016: this document transposes the guidelines of Directive 2012/27/EU of October 2012 of the European Parliament and of the Council, in relation to energy efficiency. This decree applies to those companies that have at least 250 workers or a business volume that exceeds 50 million euros and establishes the obligation to undergo an energy audit every four years, covering at least 85% of total consumption. It is equivalent to having an energy or environmental management system implanted and certified by an independent body, including an energy audit according to the guidelines of the regulations.
- UNE-EN 16247: it is a series of standards to be met by the different auditable parts of the company. It started to be considered with the appearance of Royal Decree 56/2016.

It is composed of five parts: UNE-EN 16247-1 deals with general aspects of energy audits, UNE-EN 16247-2 is specific for energy audits in buildings, UNE-EN 16247-3 for processes, UNE-EN 16247-4 in the transport and UNE-EN 16247-5 deals with the competences of the auditors. This royal decree cites the set of standards as a method and procedure for carrying out energy audits, not only to buildings but also to any type of installation.

- Technical Building Code (Código Técnico de la Edificación, CTE): this code establishes the regulations and specifications that buildings must follow in terms of basic requirements for habitability, sustainability and safety. Besides, it contains a Basic Document of energy saving which establishes the basic requirements in energy efficiency and renewable energies that must be met in new buildings and interventions in existing buildings.
- Regulation of Thermal Installations in Buildings (Reglamento en Instalaciones Térmicas de Edificios, RITE): this regulation establishes a set of conditions that must be fulfilled by the installations of sanitary hot water, air conditioning and heating. These requirements are aimed at meeting the thermal demand through optimal and rational use of energy, seeking the implementation of renewable energy, higher energy yields and the recovery of residual energy.
- Low-Voltage Electrotechnical Regulation (Reglamento Electrotécnico de Baja Tensión): it aims to establish the framework of the technical conditions and guarantees that must be met by electrical installations connected to a source of supply in low voltage limits. It sets up standards in order to preserve the safety of people and property, ensure the normal functioning of such facilities and prevent disturbances in other facilities and services. Finally, it contributes to the technical reliability and economic efficiency of the facilities.
- Renewable Energy Plan 2011-2020: this is a plan drafted by the Government of Spain for the period 2011-2020, which defines a series of objectives and proposes new energy scenarios, always oriented towards the use of renewable energies. This plan is in accordance with Directive 2009/28 / EC of the European Parliament. Specifically, the Directive establishes the objective of achieving a minimum quota of 20% of energy from renewable sources in the final gross consumption of energy of the European Union. The same objective is established for Spain, and a minimum quota of 10% of energy coming from Renewable sources of energy consumption in the transport sector in each Member State by the year 2020.

## 1.5. OBJECTIVES

At the moment, the plant does not have a proper energy management system, it only has some spreadsheets that are used to control energy consumption from time to time, but these are difficult to analyze and it is not easy to identify where to carry out the savings. However, in order to not only provide a solution and even go one-step further in the monitoring and

realization of consumption tracking, but also to facilitate the implementation of actions leading to efficiency measures in the installation, a new project has been proposed. It consists of the definition and implementation of an energy management system based on the latest regulations about energy efficiency: the ISO 50001.

The main objectives that are intended to be reached with the project are the following:

- The implementation of a more agile and intuitive system that allows to monitor consumption, act against deviations and even anticipate them.
- To have a database on the energetic behavior of the plant.
- To make an evaluation of the current state of the plant.
- To search for viable efficiency improvements. Those reduce energy consumption and allow a more efficient use of the available resources.
- To search for potential savings in the Operational Expenses (OpEx, from now on). According to the files provided by the company, expenses have been increasing in recent years and, it is expected to follow the trend for the years to come. It is important to highlight that a minimum saving in consumption implies a great saving in the OpEx.
- The implementation of ISO 50001:2018 standard, as it has been done in other plants of the same company. This will provide transparency in management, help evaluate and prioritize the implementation of new technologies and facilitate integration with other systems.
- To help in complying with the strategies and action plans established by the European Union.

## 1.6. METHODOLOGY

As previously mentioned, the final objective of this project is the implementation of a management system according to the ISO 50001 that includes a series of measures and actions aimed at reducing energy consumption and consequently, economic savings at the plant. That is why a monitoring system will be installed in the plant. As it is a completely new system to install and there is a limitation of time, it has been decided to start looking for measures to improve the management of electricity, which is the main consumption. In future phases, steam, gas or compressed air will be studied.

For this, it is necessary to deepen the knowledge about the pharmaceutical plant in the first place. It will be necessary a description of the processes that take place, as well as the equipment and installation in general, of the operating conditions and consumption to determine the current energy performance of the plant.

Once these data are collected, the equipment or processes will be grouped according to their consumption and a series of analyzers will be installed. These devices will allow an in-depth study thanks to the deZem software, an energy control software that verifies, processes and

stores the measurements of the equipment in a database. By accessing a database, the data will be represented and analyzed to identify potential savings.

At the same time, it will be necessary to understand what an energy management system consists of and become familiar with the ISO 50001:2018 in order to be able to develop the project according to its requirements. The purpose of this regulation is to facilitate the organization's establishment and implementation of systems and actions that help to improve its energy performance continuously. Its application will allow a more efficient use of the different types of energy used, as well as the reduction of gas emissions or the improvement of competitiveness.

With all this, the bases for the implementation of the system in the plant will be established. A study about what practices and technologies currently exist and which could be carried out to improve the energy efficiency of the pharmaceutical plant according to the results obtained with deZem will be done. It will also include a small economic analysis of the project and possible savings measures to adopt.

Finally, to improve efficiency, KPIs will also be established. With them, it will be possible to evaluate, analyze and monitor the processes, equipment or areas of the plant that consume the most energy.

## **1.7. TIMELINE**

The project started in October 2018 and it ended in June of 2019, taking into account that 20 hours were employed weekly distributed over four days, which is 5 hours a day. All these activities have been compiled in the following Table 1.

It should be noted that with respect to the initial schedule, times have been modified for several reasons. First, the choice and accuracy of the monitoring equipment took more time than expected because of the plant specifications. Besides, the initial quotation did not include all the measures expected, that is why it was necessary to extend it.

In addition, in order to install this equipment in a safe environment, it had to be installed under certain conditions. During the realization of the project, the plant was involved in a series of changes that slowed down the connection of the equipment to the network. Finally, when working with subcontractors and international suppliers, communications are not immediate.

Table 1. Timeline of the project

Id.	Task	Start	End	Duration	T4 18			T1 19			T2 19		
					oct.	nov.	dic.	ene.	feb.	mar.	abr.	may.	jun.
1	<b>INFORMATION COLLECTION</b>	17/10/2018	15/03/2019	87d									
2	Documentation	17/10/2018	15/03/2019	87d									
3	Initial study of the plant	17/10/2018	20/11/2018	20d									
4	<b>MONITORING SYSTEM</b>	09/11/2018	16/05/2019	108d									
5	Suppliers evaluation	09/11/2018	22/11/2018	8d									
6	<b>deZem System</b>	22/11/2018	16/05/2019	101d									
7	<b>Hardware</b>	22/11/2018	11/04/2019	81d									
8	Selection	22/11/2018	15/03/2019	66d									
9	Installation	27/03/2019	11/04/2019	10d									
10	<b>Software</b>	05/02/2019	26/04/2019	48d									
11	Training	05/02/2019	27/03/2019	30d									
12	Manual elaboration	16/04/2019	26/04/2019	8d									
13	<b>Start-up and evaluation</b>	27/03/2019	16/05/2019	30d									
14	<b>ENERGY ANALYSIS</b>	11/04/2019	06/06/2019	33d									
15	Current situation of the plant	11/04/2019	21/05/2019	23d									
16	Saving measures	22/05/2019	30/05/2019	6d									
17	Economic study	31/05/2019	06/06/2019	4d									
18	<b>ISO 50001</b>	05/03/2019	17/05/2019	44d									
19	Requirements	05/03/2019	03/05/2019	36d									
20	Templates elaboration	07/05/2019	17/05/2019	8d									

## **2. ISO 50001 IMPLEMENTATION IN THE PLANT**

Every organization should try to function in the most efficient way in terms of energy and, at the same time, should seek for continuous improvement. However, this is not only the task of the personnel that is in constant contact with the machines and processes, it must be the entire organization from the technicians to the management itself. For this, it is necessary to create solid foundations that ensure positive changes and guide the entire company towards continuous improvement (Junta de Castilla y León, 2014).

Energy efficiency is a continuous process that is not achieved with a single activity: measures must be identified and updated constantly. These types of programs are called energy management systems (EMS). Therefore, environmental management refers to the set of actions and processes that allow a company to reduce its environmental impacts and increase its efficiency to achieve economic, environmental and operational improvements (Gamazo López, 2018).

In addition, with energy management systems, the competitiveness of the company increases, not only economically, but also because the company projects an image of environmental awareness. EMS offers a framework for environmental management and involves tasks such as training, inspections, establishing a policy and objectives, risk management, etc.

An environmental management system is based on the Deming cycle: Plan, Do, Check and Act (PDCA). This PDCA model provides an iterative process used by organizations to achieve continuous improvement. It can be applied to an environmental management system and to each of its main elements. Besides, the EMS is complementary, compatible and embeddable with these other management systems (Junta de Castilla y León, 2014).

When implementing an environmental management system, it can be done officially, following the regulations and requesting their corresponding recognition or certificate. But it can also be done following or not the regulations but without asking for recognition.

There is currently a fundamental standard in which the design of a management system can be based and this is ISO 50001. It is an international standard that aims to facilitate organizations to establish management systems and processes aimed at improving energy performance, including energy efficiency and the use and consumption of every type of energy. The standard provides a framework of requirements to develop and implement an energy policy that will not only help to improve the use of energy in a more sustainable way, but also seek to reduce costs and protect the environment. Through the establishment of objectives, goals and action plans, opportunities can be identified, documented and monitored, and a continuous and systematic improvement of the policies and energy performance of organizations can be done. The practices for the design and acquisition of equipment, systems, processes and personnel that contribute to energy performance are also included (UNE-EN ISO, 2011).

It can be used by any organization that wants to reduce energy consumption, improve efficiency and optimize both productivity and profitability.

As previously commented, it provides a framework for the development of EMS in organizations. This standard deal mainly with the use and consumption of energy, the measurement and monitoring of co-consumption, and the development and implementation of a management plan to improve energy performance of the organization. Consequently, the purpose of the standard is to lead organizations to reduce their energy consumption and, therefore, greenhouse gas emissions and other environmental impacts.

So, the four stages that make up the Deming cycle are developed, applied to the ISO 50001 standard (Junta de Castilla y León, 2014):

- Plan: the first step towards the continuous improvement is the energetic planning. It corresponds to the point 4.4 of the norm. It includes the different aspects related to the consumptions and energetic uses of the manufacturing plan through an energetic revision of the past and present behaviors. Those activities that have a significant impact on the identified energy uses, they will be susceptible of improvement and, therefore, analyzed to later establish the action plans and the goals to be achieved.

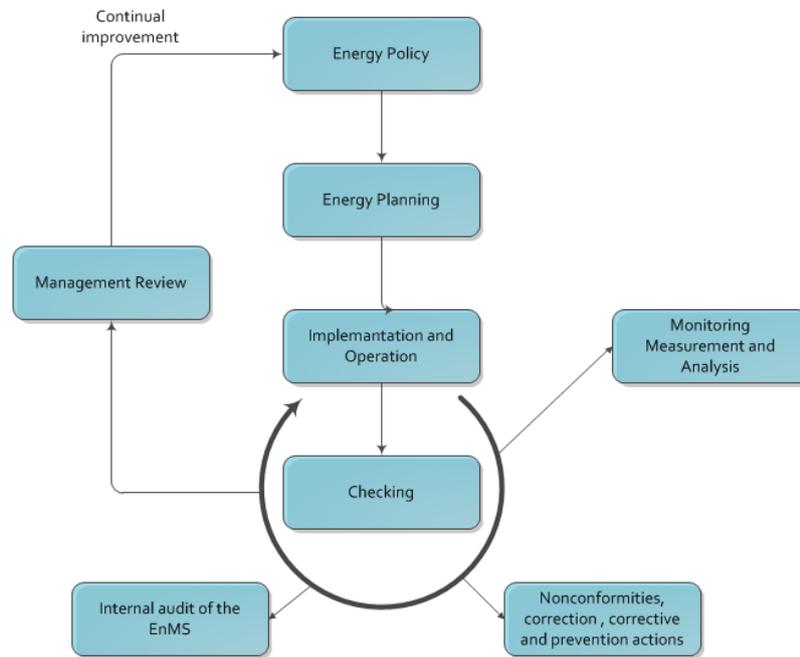
Based on all the information obtained, a consumption baseline will be established to subsequently measure the energy performance of the organization. In addition, KPI's actions plans and goals will be designed according to it.

- Do: this phase corresponds to the point 4.5 of the norm. Those action plans designed in the previous phase, will now be carried out so as to lay the foundations to implement the EMS. Some of the key activities to achieve the success of the implementation of the EMS will be to ensure, through training plans and awareness campaigns, that all the employees of the organization are able to perform their duties and ensure that they are aware of the benefits of the EMS. The communication of the same within the organization will also be very important as well as the control of the fulfillment of the criteria of maintenance and operation.

What is more, once measures are taken, those results that generate a significant impact on energy performance, must be recorded to later be followed and controlled.

- Check: this phase corresponds to the point 4.6 of the ISO. So once the EMS is implemented, it is necessary to wait for a period of time to see if goals and objectives are achieved. For this, monitoring tools will be used to evaluate the performance and compare the results with what was expected. In case of not fulfilling the initial expectations, measures will be taken to adjust it to the expected objectives. Before this preventive or corrective measures, improve actions will be taken. Again, all of this must be recorded.
- Act: finally, this phase corresponds to the 4.7 of the norm. After the end of the trial period, the management will review the EMS in order to ensure that it is adequate, and if not, make the necessary changes to improve energy performance.

This international standard incorporates energy management into the usual practices of the organization as Figure 5 illustrates:



**Figure 5.** ISO 5001 system model

*Source:* own elaboration from the ISO 50001 document (UNE-EN ISO, 2011)

The structure of ISO 50001 is designed according to other ISO management system standards, in particular ISO 9001 (Quality Management Systems) and ISO 14001 (Environmental Management Systems).

In the following section, the actions that are to be carried out by the pharmaceutical manufacturing site to implement this system are presented:

## **2.1. REQUIREMENTS OF THE ENERGY MANAGEMENT SYSTEM**

### **2.1.1. GENERAL REQUIREMENTS**

Here there are the main functions that the plant must implement to develop the energy management system:

- Establish the general guidelines of the Energy Management System of the pharmaceutical plant that will serve as reference framework for the operation and organization of the plant.
- Define a clear energy policy of commitments and objectives on the part of management for the correct functioning, implementation and improvement of the EMS.
- Define and document the scope of the system, as well as establish the limits of it.

- Establish, document, implement, maintain and improve the EMS in accordance with ISO 50001.
- Describe the procedures for document control, internal audits, corrective and preventive actions and revisions.
- Establish training plans to meet the training requirements.

### **2.1.2. MANAGEMENT RESPONSIBILITIES**

The first step for the implementation of the ISO is the definition of the team that will carry out the task. The standard establishes as a requirement that there are management representatives directly involved in the project in order to guarantee that the energy activities are carried out considering the requirements of the ISO 50001 and also lead the continuous improvement of the activities of the plant. In this way, commitment by the entire organization will be guaranteed. For this, the Management of the plant must carry out the following tasks in a generic way:

- Communicate the importance of energy management.
- Establish and approve the energy policy, limits, scope and targets. With respect to scope and limits, the site can start by implementing the system in an area of the factory or, as in the case of this project, by monitoring and analyzing a type of energy. But this does not prevent that in the future, the scope will change and be expanded.
- Provide the necessary resources to develop the EMS.
- Appoint the management representative and approve the creation of the energy committee.
- Carry out periodic reviews.

What is more, ISO 50001 establishes the need to appoint a Management Representative with the appropriate skills and competencies who, independently of other responsibilities, will be the real responsible for the correct management of energy in the organization. This person should:

- Ensure the correct implementation, development and improvement of the EMS in accordance with the requirements of the Standard.
- Identify people, with authorization from the appropriate level of management, to work with them in support of energy management activities. These will form the energy management team.
- Report on the energy and system performance to management.
- Create awareness in the energy issue at all levels of the organization.

Finally, as previously mentioned, to help the designated representative, it is necessary to have an Energy Committee. As the pharmaceutical company is a large organization, this committee should be formed by an interdisciplinary team to compromise all parts of the organization. Their main tasks will be:

**Definition and implementation of an energy management system**

- To perform the measurement and monitoring of energy consumption, as well as the energy diagnosis.
- To design and develop objectives, plans and actions aimed at the continuous improvement of the plant.
- To establish written rules for energy saving.
- To inform the representative and senior management.

Below there is a possible organizational chart for the implementation of the EMS:

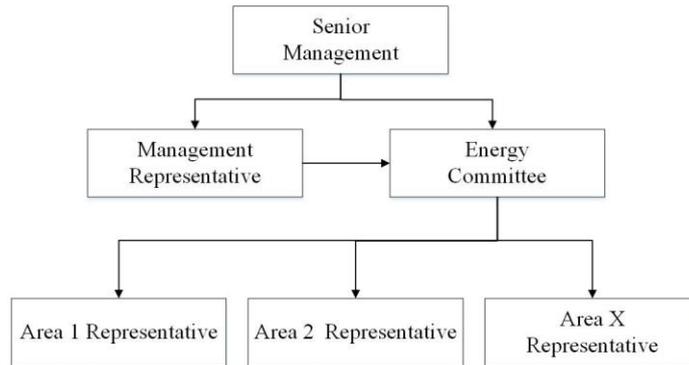


Figure 6. Organizational chart of the plant for the implementation of the EMS

In order to facilitate the visualization of the responsibilities, here there is Table 2 with the activities, the people in charge and the task to develop. Only the responsibilities of the positions already defined are detailed. Also, there is the explanation of the hierarchical level of responsibilities used.

Table 2. Responsibilities

<b>DECIDE (D)</b>	Resolve, define and make decisions that affect the effectiveness of the Energy Management System
<b>RESPONSIBLE (R)</b>	Ensure that the function and/or task entrusted is carried out efficiently.
<b>INFORM (I)</b>	Communicate about issues that have implications in the Energy Management System
<b>COLLABORATE-COMPLY (C)</b>	Perform some of the tasks described in the Energy Management System documents

<b>RESPONSIBILITIES TABLE</b>	<b>Management</b>	<b>Management Representative</b>	<b>Area 1 Representative</b>	<b>Area X Representative</b>	<b>Other Areas and Services</b>
Energy policy	D	C			C
Legal and other requirements	D	I-C			C
Energy review	D	R - I			C
Energy baseline	D	R - I			C
Energy performance indicators	D	R - I			C
Objectives, targets and action plans	D	R - I			C

Competence, training and awareness	-	R			C
Communication	D	R			C
Documented information	-	D			C - I
Operational controls	-	R			C
Design	-	R			C
Procurement of energy services, products and energy	-	R			C
Monitoring, measurement and analysis	-	R - I			C
Evaluation of compliance with legal and other requirements	-	R - I			C
Internal audit	D	R			C
Non-conformity and corrective/preventive actions	-	R			C
Control of records	-	R			C
Management review	D	-			C

### 2.1.3. ENERGY POLICY

The energy management system describes a series of activities through which the Energy Policy is developed. This establishes the basis for defining performance goals and helps integrate energy management into the culture of the organization.

The company in question is a multinational, so the energy policy is defined for the entire group. The management of the company at the group level will be responsible for defining it and ensuring that it is reviewed and updated periodically. At the study site, the management representative will disseminate the policy through communications and posters. It can also be included in the plant system so that all employees have access to it.

### 2.1.4. PLANNING

As it has been mentioned in the explanation of the Deming cycle applied to ISO, prior to implementing the EMS, energy planning must be carried out. This will establish a series of steps that will allow the organization:

- Identify and track the legal requirements and other necessary requirements.
- Make an energy review of the plant to identify which activities affect the use and consumption of energy.
- Establish an energy baseline
- Develop KPIs
- Establish objectives, goals and action plans.

The Energy Committee should meet periodically, at least once a year, to review the planning and the site manager will be responsible for approving the elaboration or changes introduced and communicating this planning to all levels of the organization. In case of identifying any

non-conformance, the pertinent modifications will be made and control and follow-up will be increased, convening meetings every 6 months. All this must be documented and registered.

**LEGAL REQUIREMENTS AND OTHER REQUIREMENTS**

The pharmaceutical plant must establish a methodology to identify and maintain all the legislation and energy efficiency regulations that apply to it.

In terms of legal requirements, the person in charge must identify the current legislation on energy efficiency that comes from the European Union, Spain and Madrid. For this it will be necessary to have the official bulletins, municipal publications or regulatory databases.

Additionally, the ISO standard refers to "other requirements" to corporate strategies or policies, sectoral initiatives, or any other type of voluntary framework or initiative.

To establish and maintain a record that allows monitoring the evaluation of compliance with legal requirements and other requirements that are applicable, the attached Table 3 is proposed:

*Table 3. Legal and other requirements documentation*

Requirement title	Description	Responsible	Action plan	Identification date	Last review date	Compliance	
						Yes	No

**ENERGY REVIEW**

The energy review is the process of development and analysis of the energy profile of the plant that supports energy planning. It contemplates the analysis of energy consumptions from different sources, in order to understand if it is working properly and in which areas of the process the significant use is concentrated.

To be able to carry it out, it is necessary first to have a record of the current and past real consumption. Here in the plant, the past records are collected in the Excel sheet. The problem that this is a report of the consumptions in general, so it is not specified to which area or process corresponds. For this, the energy monitoring system has been installed.

Therefore, in the first place, it will be necessary to analyze the use and consumption of energy, identifying past and current sources and uses and consumption. Based on this record, the areas of significant energy uses will be identified. The facilities, equipment or processes that significantly affect it will be identified. Likewise, other variables will be identified, and the current performance determined. Finally, opportunities for improvement will be identified, prioritized and recorded.

To register all these energy variables of the plant, the following Table 4 is proposed:

Table 4. Energy review

Installation	Source of energy	Consumption /Generation	Use description and energy generation	Equipment, facilities and processes	Variables affecting energy use	Year 0	Consumption/ Generation year 0 (MWh)	Consumption/ Generation actual year (MWh)	High potential for improvement identified

Therefore, the methodology used to perform the energy review will consist of a process like the one represented below:

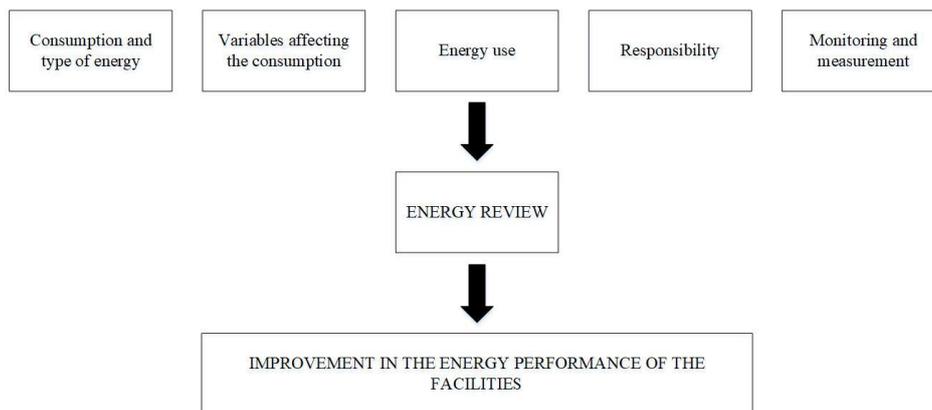


Figure 7. Energy review process

### ENERGY BASELINE

Once the energy review of the plant is made, a consumption baseline can be established. This will allow comparisons to evaluate advances or setbacks in energy once the EMS is implemented. It will be necessary to review and update it in case any new measure or change of operation or equipment is introduced.

### ENERGY KEY PERFORMANCE INDICATORS

To perform the correct monitoring and measurement of the energy performance of the plant, it will be necessary to establish a series of indicators. These will be compared with the previously identified baseline. It is very important that the organization correctly identifies them and then makes improvement decisions. These should be exhaustive enough to get the overview and turn the detail. The following are proposed. Depending on the interest and overall, the analysis, they can be calculated monthly or annually:

**Definition and implementation of an energy management system**

- Energy consumption per area (kWh/area).
- Energy cost per area (€/area).
- Energy consumption per process (kWh/process).
- Energy cost per process (€/process).
- Temperature vs Consumption vs Production.
- Humidity vs Consumption vs Production.
- kWh/person.

**OBJECTIVES, TARGETS AND ACTION PLANS**

Once the base performance indicators are determined, the objectives, targets and action plans to be followed must be defined. These will be established annually in order to continuously improve the use, consumption and energy performance of the pharmaceutical center.

From the energy review, the establishment of the baseline and the KPIs, an analysis will be made to see possible points of improvement. These will be registered in a table like this one:

**Table 5. Improvement opportunities detected documentation**

N° Action	Saving opportunity description	Type of opportunity	Investment (€)	Time			Responsible	Follow up	Results		
				Initial date	Final date	Investment return period (years)			Annual energy saving (kWh/year)	Annual economic saving (€/year)	Avoided CO2 emissions (Tn/year)

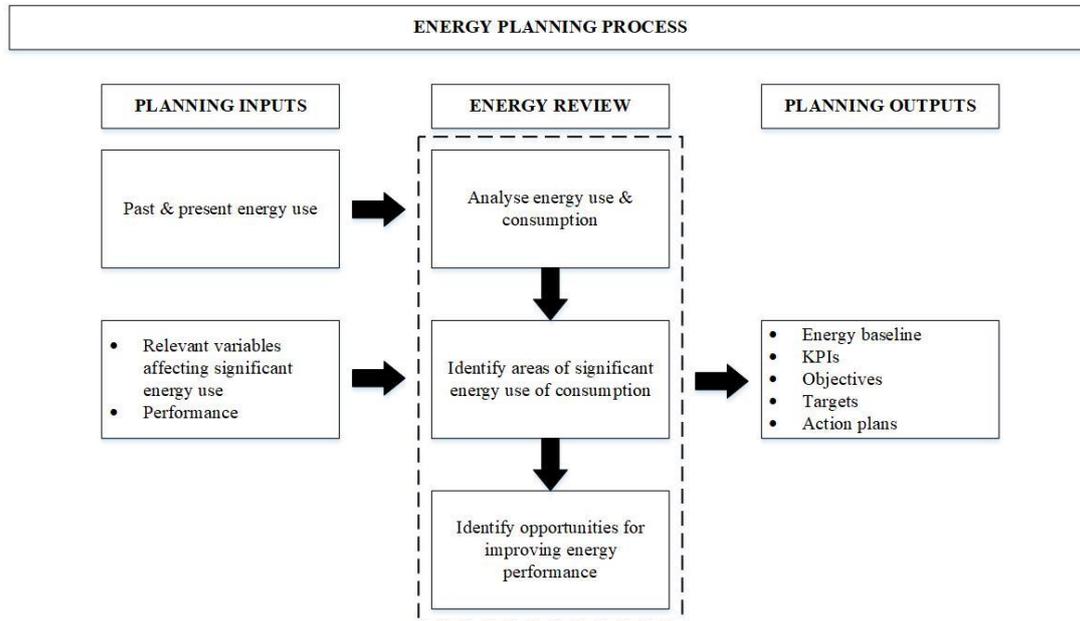
Then the objectives will be established based on the proposed energy saving measures. These must be quantifiable and coherent with the energy policy. The goals are the quantitative measures of performance to comply with the previous ones.

Finally, the action plans must include the designation of responsibilities, means and anticipated terms and methodology through which to verify the performance improvement. In Table 6, a record of objectives and targets is attached.

**Table 6. Objectives and targets record**

Objective	Target	Responsible	Time limit

Therefore, the planning process can be represented as follows:



**Figure 8.** Energy planning process

### 2.1.5. IMPLEMENTATION AND OPERATION

Once the action plans have been established and approved, the implementation and operation phase can begin. For this, it will be necessary to check the available resources and the available budget for it.

#### COMPETENCES, TRAINING AND AWARENESS

The standard establishes as a requirement that all personnel involved must be aware of the need to control energy and its uses. In addition, the personnel will have the qualification, training and enough experience to carry out the tasks related to the significant uses of energy.

That is why, the plant must develop procedures in which it describes the guidelines of the EMS aimed at ensuring that training, awareness and competence needs of personnel and external contractors are contemplated and met.

The training will be given to newly hired personnel and other collaborators as established in the annual HSE training plan.

It should also be noted that when there is some kind of incident or occasional environmental need or environmental needs, training and / or information on the subject will be immediately given.

This training system will include courses of different duration, depending on the agenda that is taught. In addition, depending on the role and responsibilities of each person in the organization, some courses or others will be taught. All the courses taught will be registered, as well as the assistance of the workers.

## COMMUNICATION

The function of communication is to ensure environmental information between the different levels of the pharmaceutical plant, as well as to attend relevant communications from interested external parties.

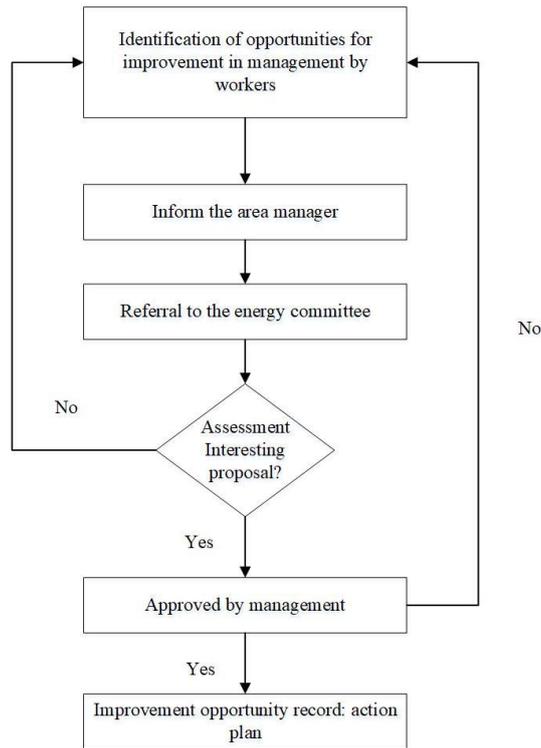
All possible environmental communications are included: internal, external, ascending and descending, both between the different levels of the company and environmental communications from interested external parties (complaints, complaints, complaints or general information).

- Internal communication: it may include, among other things, responsibilities, information on energy aspect, policy and objective, energy generalities, risks for non-compliance with procedures, non-conformities, etc.

All employees of the Company, not necessarily only the Energy Committee, make this communication. The most suitable channels for the transmission of information are the verbal and written channel.

- External communication: translates into the issuance of information abroad either on its own initiative or because of a requirement from an external interested party.

As new ideas or problems arise, the communication process will take place as follows:



**Figure 9.** Communication process

## DOCUMENTATION

The regulation establishes that a process of control and management of documents related to the system is carried out. The documentation can be on paper or preferably in digital format so that it is easier to access by employees of the company.

The documents that define the Energy Management System are intended to provide a detailed description of the characteristics and particularities of it.

Four levels of documentation are established:

- Level 1: Energy Management Manual. The description, requirements and commitments of the company's Energy Management System are included in the basic document. The Energy Committee, in charge of its control once it has been reviewed and approved by the Management, prepares it.
- Level 2: Energy Management Procedures describe the methodology to be followed to ensure the correct implementation and monitoring of the System. They are complementary documents to the Manual and constitute a tool of habitual use in the operation of the facilities. They define the responsibilities in each activity and describe the systematics for the performance of those operations that can give origin to significant environmental effects. All of this to give compliance with applicable legislation, requirements of the standard or other requirements. Each of these will have the following sections: objective, scope, references, responsibilities, content and annexes.

- Level 3: Instructions, technical regulations, environmental legislation and other documents.
- Level 4: Records or emails.

For better control of the EMS documentation, the documents will have the following nomenclature:

**Table 7. EMS documentation**

	<b>Code</b>	<b>Number</b>	<b>Procedure to which belong</b>
<b>Energy Management Manual</b>	EMM	00	-
<b>General Procedures</b>	GP	XX	-
<b>Annexes and complementary registrations</b>	A	01-XX	XX

### OPERATIONAL CONTROLS

Operational control is applied to all those processes, facilities, products and services that have a significant impact, either directly or indirectly, in the Energy Management of the pharmaceutical plant.

The procedures and instructions (in cases they are necessary) describe the methodology to control the activities and processes, ensuring that they are carried out in accordance with the requirements of the legislation, other requirements and the company's Energy Policy.

### DESIGN

This requirement is applicable to the design of new, modified and renovated facilities, equipment, systems and processes that can have a significant impact on the organization's energy performance. It requires the plant to consider energy performance improvement opportunities when performing these activities.

### PROCUREMENTS OF ENERGY SERVICES, PRODUCTS, EQUIPMENT AND ENERGY

When purchasing energy services, products and equipment that have, or may have, an impact on the significant use of energy, the pharmaceutical plant must inform suppliers that the purchases will be partially evaluated based on energy performance.

Therefore, the plant has to establish and implement requirements to evaluate the use and consumption of energy, as well as the energy efficiency during the planned or expected useful life when acquiring products, equipment and services that use energy that may have a significant impact on performance. energy of the organization.

The organization shall define and document the energy acquisition specifications, when applicable, for the effective use of energy.

**2.1.6. PERFORMANCE EVALUATION**

**MONITORING, MEASUREMENT AND ANALYSIS**

According to the standard, an analysis and monitoring of the consumptions and uses will be made through the energy monitoring system installed with the deZem software. With this tool, the previously established KPIs will be compared with those that may arise in the future, with the baseline. This will check if the objectives are met and if it is not, take preventive and corrective measures.

From all the information obtained in the energy review and after the identification of the variables and the KPIs and the measurement of all the aspects, it will be possible to monitor the energy performance. All this information can be gathered in the table like the following Table 8:

*Table 8. Monitoring, measurement and analysis record*

	<b>Reference value of the KPI (kWh)</b>	<b>Improvement of the KPI (kWh)</b>		<b>Target applied to the baseline (kWh)</b>	
<b>Date</b>	<b>Baseline</b>	<b>Actual consumption / Expected consumption</b>	<b>Actual cumulative energy savings</b>	<b>Energetic goal expected</b>	<b>Cumulative expected energy goal</b>

**INTERNAL AUDIT**

The standard requires that internal audits be carried out to guarantee compliance with the requirements of this and the effectiveness of the system implemented. This will identify non-conformities and before these measures will be designed.

The Energy Management System Audit is the basic tool to evaluate the degree of implementation and maintenance, as well as to diagnose energy behavior in accordance with the plans and requirements established in the Manual and procedures, and to provide information on the results to the direction.

The auditor may be constituted either by internal personnel or by personnel external to the Company, but in any case, the persons who perform the audits will be independent of the

activity that is subject to review and will have the required qualification. This person or team must objectively evaluate and document if the system complies with the regulations.

The process will consist in:

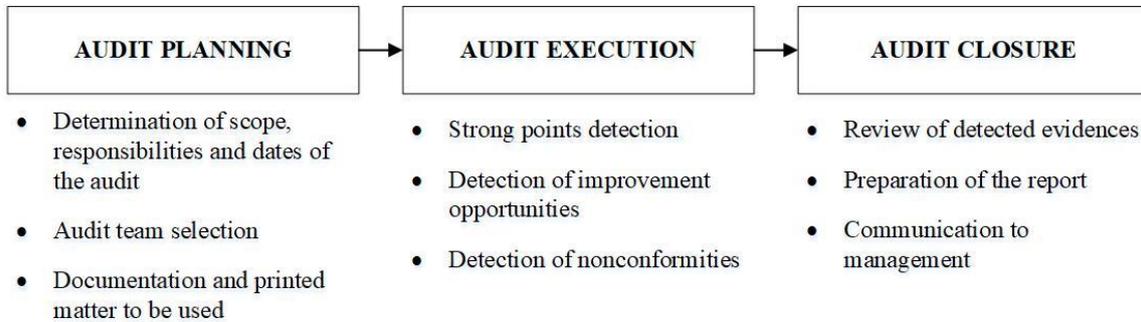


Figure 10. Audit process

### NON-CONFORMITIES, CORRECTIVE AND PREVENTIVE ACTIONS

The standard requires that processes be defined to identify situations where the requirements of this are not met. Not only is it necessary to define the process to identify, but also to establish the pertinent actions. In this way, you can act quickly to correct it.

Procedures addressing non-conformities should include:

- Analysis of the cause of non-conformance
- Identification and implementation of corrective actions
- Modification of existing controls, if necessary
- Establishment of preventative measures where appropriate
- Recording any changes in written procedures resulting from corrective or preventative actions
- Ensuring follow-up actions are in place to ensure satisfactory resolution of the non-conformance, and Non conformances should be reviewed in the Management Review process and Energy Management Team/Working Group meetings.

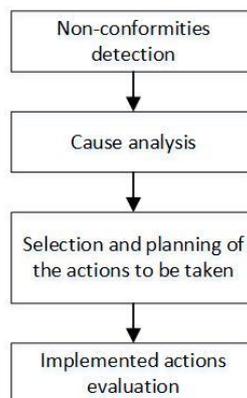


Figure 11. Non-conformities, corrective and prevention actions process

## CONTROL OF RECORDS

In order to demonstrate the effective functioning of the EMS, the pharmaceutical plant is required to keep legible, identifiable and traceable records. Records provide evidence of actions taken to adhere to the EMS requirements and comply with the ISO 50001 standard. A comprehensive system for managing and maintaining records is necessary to ensure that records are easily identified, stored and maintained for an appropriate length of time.

### 2.1.7. MANAGEMENT EVALUATION

Finally, the standard establishes that periodic reviews of the results obtained in the energy management system must be carried out. As a result of this review, management will make the relevant changes and improvements to the energy system, establish new action plans with new objectives and modifications in the allocation of resources.

The Environmental Management System is to be reviewed every six months by the management to ensure its adequacy with the applicable requirements and the Energy Policy, as well as to verify its continued effectiveness.

This revision may be carried out on an extraordinary basis outside the established period, provided that the special circumstances of the system so require.

Management review can be considered successful if the information obtained as a result is relevant and presented in a meaningful way that leads to effective decision making. The decisions taken should be aimed at improving the energy performance and should ensure that the actions required by those decisions are implemented.

In view of all these documents, a report is drawn up, signed by the Director General, which includes:

- Conclusions on the suitability, adequacy and effectiveness of the Management System.
- Opportunities for improvement.
- Any need for changes in the management system.
- Any involvement for strategic management.
- Resource needs.

### 3. ENERGY MONITORING SYSTEM

#### 3.1. INTRODUCTION

The systematic monitoring of energy consumption is the beginning for all energy efficiency improvements: it helps identify usage patterns, provides all kinds of reports and comparisons (year-by-year, building by building, plant by plant...) and finally demonstrates the effectiveness of specific projects (ICF Consulting Limited, 2015). It provides real-time data and in a remote mode.

The range of possibilities is broad in terms of functionalities. With real-time monitoring and consumption accounting, it is easier to establish an internal diagnosis and propose actions and measures for the automated active control of demand.

In addition to its functionality as an internal measurement system, it allows to monitor and even anticipate technical incidents associated with the supply and operation of the equipment, reinforcing the technical management and maintenance operations.

Generally, the system is composed of four parts (Eficienergética): the monitoring equipment, the data collector, the software to analyze and control and the communication system between the two previous elements. In the following Figure 12, the four different parts are represented:



**Figure 12.** Energy Management System configuration

The monitoring equipment is a basic energy management tool capable of providing the energetic properties of the area to which it is connected. The information is shown in real time and depending on the type of device, it will supply certain energy parameters of the facilities. It can be modular or wireless.

Nowadays, there are countless devices to make measurements. From meters, sensors, network analyzers... These meters are usually placed in the main points of energy consumption of the installation and procure very precise information.

However, the information these devices provide is not stored on the machines themselves. That is what the datalogger or data collector is for. These devices allow the acquisition, collection and processing of energy data through standardized interfaces.

The software or energy management platform is the element in charge of processing and processing the raw information of the measures taken in order to facilitate the interpretation of the data and the decision making of the energy manager. Users can access to the consumptions collected in the servers and carry out the analysis with the software from different locations and equipment. There are countless software solutions such as the one from Siemens, Circutor, GE or EBO.

This software allows the organizations to know precisely how much is consumed, where it is consumed and when it is consumed and with it, optimize the energy uses and consumptions of their facilities.

Finally, in order to transfer the information in a safe way, there is the communication system between the data collector and software platform. They can be local (radio modems) or global in scope (routers and GPRS/3G modems). This selection will depend on the characteristics and requirements of the organization. It is important to study the size and distribution of the plant so as to see if the connection between the different parts will be possible to establish physically or via modem for example.

Therefore, the choice of software and energy management tool requires, first, a definition of the objectives that the company proposes with its acquisition, and a research and analysis of the functionalities and usability offered by each of the tools that already exist in the market.

In relation to the issues to be assessed or taken into account when selecting both hardware and software for energy management, there are multiple aspects to consider and decide which one of them to select such as:

- The kind of data is required to be managed: electric consumption, gas, water, gas oil, steam, temperatures, pressure... In order to select the adequate monitoring device.
- It is necessary to know if the building already count on any devices to measure that can be used, and if it is compatible with other manufacturers.
- The level of accuracy and resolution required in the collection of data and analysis: every day, hour, monthly... Also, if only one phase can be controlled and then calculations to extrapolate it to the whole circuit or if measures must be as accurate as possible.
- The type of analysis that is needed: consumption and cost charts, tables, alarms, reports or other indicators.
- From what and how many devices shall the information be accessible.
- The selection of those who will oversee the monitoring and analysis of the plant: departments of production, maintenance, engineering, financial, administrative.

- The integration of the new systems with the ones already working in the plant or even the possibility to connect it with other plants in order to have a single management system.
- The possibility to further develop or expand the system.

These are only a few examples of points to consider but there are many issues that need to be addressed when taking the decision of implementing an energy management system. Depending on the complexity of the installation both in size and in process variability, different solutions could be adopted. There is no a single solution.

### 3.2. DEZEM MONITORING SYSTEM

Since 2003, the German company deZem has been developing and providing energy management systems (deZem). The solutions they offer can be characterized as safe and efficient, and they provide flexible systems, easy to use and adapt. They supply clients with tools that allow them to record, visualize, control and optimize consumption autonomously, accurately and immediately.

The systems are in fact being used successfully worldwide by large companies such as Bayer, Siemens, Lufthansa, Nestle, Vattenfall, OSRAM. In addition, large public real estate managers, universities, data centers, international mines, industrial bakeries, schools or nurseries are some examples of centers that have been using this system.

The deZem system solves all technical issues regarding energy management system. It has a modular structure and is offered as a turnkey solution including hosting service. However, each component can also be used on its own or in combination with third party systems.

So, what the company offers in its portfolio is:

- **Hardware for flexible data collection:** deZem offers data collectors, multifunction modules, electrical meters and portable briefcases to acquire and process data of any kind, in real time, through standardized interfaces. deZem offers safe and versatile devices. In addition, as mentioned before, its configuration is compatible with solutions from other suppliers.
- **deZem energy controlling software:** it is the means through which to manage and configure the energy control system, both in a technical and organizational way. It is a technically matured and very innovative solution, based on the cloud, so a local installation is not necessary. All measurements converge on powerful servers, where they are verified, processed, and stored in databases. From the computer, tablet or mobile phone, the server can be accessed, and representation and analysis of the data can be done. Alarms and reports can also be configured to be sent automatically.
- **Customized services:** they also provide specific and effective services to the client throughout the duration of the projects. They offer training courses and workshops,

consultancies and pre-audits and support in the development of metering concepts, installation and configuration.

So, metering, controlling and analyzing energy consumption is widely known as the most effective method to increase energy efficiency and reduce energy costs. With deZem technology, the requirements of ISO 50001 are easily satisfied.

For this project specifically, it will be necessary to develop the concept of monitoring: what we want to know and at what level of detail. A series of analyzers will be installed in the general panel and interfaces will be configured so that all the information can be collected in industrial PCs.

### **3.3. SYSTEM IMPLANTATION**

Upon arrival to the plant, it was necessary to get familiar with the plant in order to see what type of system would be appropriate to install. All the information available about its general consumptions, facilities and single-line diagrams, operating regime, processes, equipment and previous measures was gathered.

As previously stated, there was no operating system for consumption monitoring; only an Excel sheet with the monthly consumption of the main resources (electricity, gas and water) was available.

The idea of the project was to implement an energy management system that allows not only to know consumption in a more fluid, deep, truthful and dynamic way but also, to facilitate the analysis or even the forecast of them.

Since there was a limited time for the project and it was a completely new system to be implemented, it was decided to start with the monitoring of electrical consumption in the first place. Nevertheless, the idea was to later extend it to gather data about gas, water, compressed air and steam.

Therefore, to carry out consumption monitoring, it was necessary to install a series of devices that measure and store various electrical parameters that would be used later for the analysis.

#### **3.3.1. HARDWARE SELECTION**

Right after arriving to the site, some monitoring equipment were found. Previously, the plant had 12 SATEC measuring equipment installed in the low voltage general switchboard, from now on, LVGS and capacitor banks just like the following one:



Figure 13. SATEC equipment

Specifically, there were analyzers in the following circuits:

Table 9. Previous metering points

1	Planta Técnica
2	Enfriadora 1
3	Enfriadora 2
4	Enfriadora 3
5	Módulo exterior I+D
6	Líquidos
7	Semisólidos y cápsulas
8	Alumbrado
9	Transformador 1
10	Transformador 2
11	Batería condensador 1
12	Batería condensador 2

However, these devices were outdated and despite there was a proposal a few years ago to update them and create a database to access through a software to see the consumptions, finally the project was not carried out.

Besides, as there was no specific record for areas, processes or machines of the parts of the plant that consume the most and taking advantage of what had already been installed, it was decided to start by monitoring the different areas in which the plant is divided.

Furthermore, the existing single-line diagrams were out of date, so it was not possible to see which parts of each secondary board consumed more and it was even difficult to establish the traceability between the electrical boards. That is why, the update of them was commissioned to an expert.

So, the project started in the general panel of the workshop where the old ones were. Apart from the ones already installed, other circuits were chosen to be monitored. This selection was based

**Definition and implementation of an energy management system**

on those circuits that had the highest power through their phases in the old single-line diagram, as it can be seen in the Plan 6. Those were:

**Table 10.** New metering points

13	Edificio social
14	Edificio oficinas ala oeste
15	Almacén
16	Pesadas y sólidos
17	Acondicionamiento
18	Aire comprimido
19	Climatización SM
20	Emergencia

Therefore, the project began with the monitoring of 20 points. However, as the idea was to monitor the system to identify where measures to improve the efficiency could be taken, at the end the Bateria de condensadores 1 and 2 were not controlled. So, at the end 18 analyzers were to be used but this decision was taken right before ordering the equipment which means that the initial offers are for 20 devices as it can be seen in the Table 16 in the APPENDIX A: Offers.

As previously explained, to carry out the monitoring, two types of physical devices were mainly needed: the equipment that measures the different parameters of the installation and a collector that stores the data.

From the beginning, the idea of the project was to install the deZem software solution since other plants of the same pharmaceutical company had already used this software. Besides, apart from the functionalities that this type of software usually provides, it allows access to the consumption of other plants, which is a competitive advantage over other systems.

This solution only established as an equipment requirement the use of its own iPC. Its characteristics can be seen in the data sheet of the B.2. of APPENDIX B: Technical Data Sheets. deZem iPC is a Linux-based industrial computer compatible with a wide range of fieldbus protocols. This device gathers all kinds of measurement data. It stores data and, depending on the connectivity of the network, forwards it to the central deZem servers. The servers then provide the data so that it can be accessed from the plant.

However, with respect to the analyzers, the choice of devices was free. For this reason, different options and providers were consulted until reaching a conclusion.

Analyzers are high-precision measurement centers, that control and show of the main electrical parameters in single-phase and/or three-phase, three or four-wire networks (in LV or MV). The measurement is made in True Effective Value and record parameter data such as:

- Active power consumed instantaneous
- Active energy consumed in one period

- Instantaneous capacitive and inductive reactive power consumed
- Instant capacitive and inductive reactive energy consumed
- Power factor
- Harmonic distortion

In the first place, it was necessary to decide what to do with the analyzers that already existed in the plant. Two options were considered: reuse them or replace them.

Two suppliers were consulted for the update/replacement of the old analyzers and the acquisition of the new ones. So, an initial offer was requested to have an idea of the cost and work that the implementation would imply:

The first supplier contacted was SATEC, the company that had supplied the previous equipment and with which the subcontractor that is responsible for part of the installation and maintenance of the plant, works. SATEC is a global leader in the research, development and manufacturing of energy management solutions. As part of their portfolio, they offer a series of devices span from basic power meters up to high performance grid meters with advanced power quality capabilities. An initial offer included the update of the 12 existing devices and the acquisition of the 8 new ones.

On the other hand, the offer from the software company itself was studied. The company deZem offered in its quotation some modules of electrical measurements, the ZM8C and ZM8C-P. Each of them allows eight channels of measurements. In their software and configuration, these devices are identical. They only difference in that the ZM8C-P has an extra group to receive the voltage reference. What is more, up to 4 ZM8C can be connected in one ZM8C-P. Their technical sheet and configuration can be seen in the B.1. of APPENDIX B: Technical Data Sheets.

As the idea was to measure 20 points of the installation and to monitor the three phases of each of them in order to have the most accurate measure as possible, this implied that, in total, 60 measurement points were required. Since it is ideal to have all the phases of a circuit in the same analyzer, only 6 channels of the ZM8C (3 of each circuit) would be used instead of the 8 available ones. Therefore, to be able to supply all this data, 10 devices would be needed.

Comparing both offers it was concluded that, looking for the highest standardization and compatibility and, above all, the most economical offer, the best option was the one supplied by the deZem. The offer comparison can be seen in the Table 16.

However, the offer attached in Table 17, there were several points that were unclear, such as the current transformers to be used.

Since nominal current flowing through the lines is very high, the transformer converts this current into lower values so that it can be read by the network analyzer. The choice of this model is usually given by the characteristics of the installation:

- Type of connection
- Amperage range

The initial current transformers offered by the supplier did not meet the needs of the installation. As it can be seen in the single-line diagram of the low voltage general switchboard in the Plan 6, through some phases, there are more than 500 A circulating. According to the options presented by deZem in the attached technical sheet in B.3. of APPENDIX B: Technical Data Sheets, they only had transformers up to 500 A, so higher coils would be required. As this solution fell short, the company provided another option that consisted of using the Rogowski coils.

The Rogowski coil is an electronic device, used as a transducer to measure alternating current (AC) or fast current pulses.

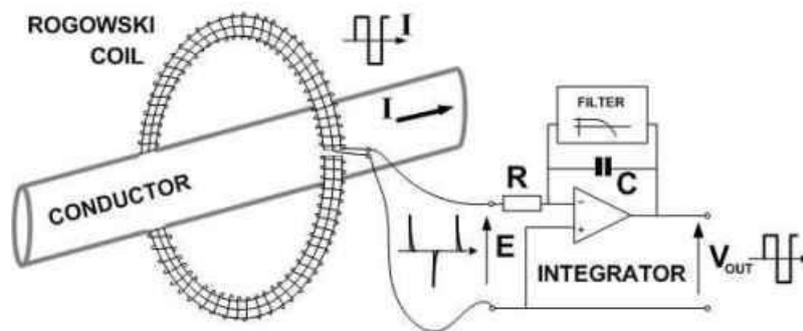


Figure 14. Rogowski coil

Source: Image taken from the article on the website Afinidad Eléctrica, written by (Koon)

It consists of a coil of wire in the form of a helix, around a circumference, like a toroid, but with an air nucleus, and the two terminals close to each other (Koon). The coil then closes around the conductor cable that carries the current to be measured. Since the voltage induced in the coil is proportional to the speed with which the current measured in the cable varies, or its temporal derivative, the output obtained in the Rogowski coil is usually connected to an integrating device to obtain the signal.

Rogowski coils reliably measure alternating current and integrate quickly and easily in existing environments. They are simple and versatile devices for current measurements in a wide range of applications ranging from microelectronic devices to high power systems in industrial installations.

An advantage of the Rogowski coil compared to other types of current transformers is that by its design they open easily and are flexible, which facilitates measuring a conductor cable without disturbing it.

Again, an updated offer was requested considering the Rogowski coils. The company sent two possible options which are attached in the Table 18: one in which they included the ZM8C and ZM8C-P modules with its proper current transformers for the parts of the facilities that accepted

this solution and the Rogowski coils and analyzers for the exceptional cases; and another in which only the coils and analyzers were used. After comparing both options, it was seen that economically, the most optimal solution was to install the Rogowski coils in all the circuits. With this decision, the final offer was requested. It is presented in the Table 19.

### 3.3.2. HARDWARE INSTALLATION

Next, each of the elements of the hardware used for measuring and taking data is presented.

First of all, in Figure 15, the Rogowski coils are presented. Each of them goes around one of the phases. Subsequently, the three coils of each phase are connected to the analyzer, in which currents, voltage, power factor, active, reactive or apparent power can be visualized. Its connection scheme can be seen in the Plan 3.



**Figure 15.** Rogowski coils and converter

Each of the analyzer must be powered so they have been connected to the electrical outlet of the transformer 2. All the analyzers have been bridged to each other through a power strip so that, in case one fails and has to be subjected to some kind of maintenance or replacement, the whole system does not need to be stopped. For the connection, k5 shielded cables of 4 braided strands have been used.

The last analyzer is connected to the iPCX as shown in the attached configuration diagram in the Plan 2. Here, the iPCX device:



Figure 16. iPCX data logger

In order to transmit the data to the deZem platform, it could be done by two different ways. On the one hand, the iPCX could be connected to the local network and thus transmit the data. However, during the start-up of the project, a new network in the plant was being implemented at the same time. As this network was still in the initial phase and may not work properly, it was decided to use the second system to guarantee the collection of the data during the duration of the project. Nevertheless, in the future, the data will be transfer through this local network.

This second option consist of connecting a modem and an antenna to the iPCX. This configuration can be seen in the Plan 4.



Figure 17. Modem and antenna

Finally, just like the analyzers, both the iPCX and the modem must be powered by a 24V power supply that can be seen in Figure 18:



Figure 18. Din rail power supply

To finish the configuration, it has also been necessary to install a 25A differential with a sensitivity of 30 mA to protect the equipment. Once each of the elements of the physical management system is explained, photos of the final configuration are presented:



Figure 19. Equipment installation I

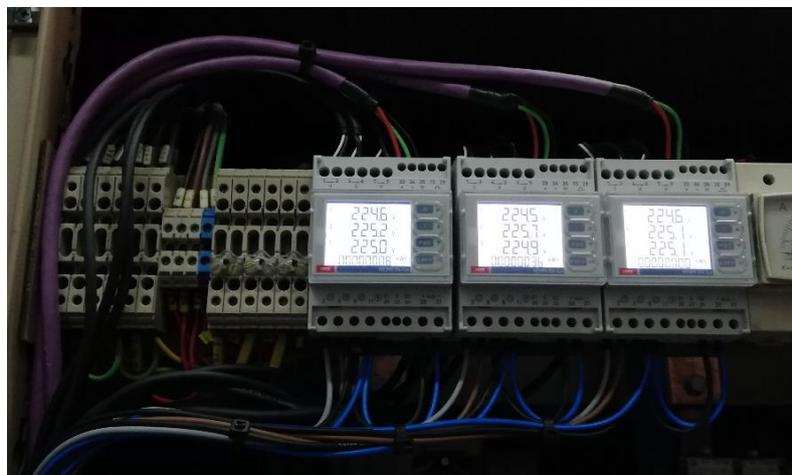


Figure 20. Equipment installation II



**Figure 21.** Equipment installation III

### 3.3.3. SOFTWARE

The deZem software is an information system oriented to the detection of savings opportunities, evaluation of the result of the measures implemented, and monitoring and control of energy flows in the facilities. Therefore, by itself, the deZem software does not save energy but it makes visible large savings opportunities that allow technicians to take measures and materialize them in the reduction of consumption and real costs: make energy management fast and efficient.

Nowadays, with the advancement of technology and the internet, there are tools in the market analysis and energy management that does not acquire a license. It is only necessary to pay for using the system on the web. This mode allows access to a cost adjusted to permanently updated software, without having to acquire or maintain servers, avoiding the risk of information loss and obsolescence.

This type of web software based in the cloud, allows access to the information from any device with an internet connection from anywhere, streamlining decision making and sharing information among various users in a simultaneous way. It might even facilitate, in real time, sharing the incidents and analyze the instantaneous behavior of a piece of equipment or part of the installation, reducing costs of intervention of technical services and operation and maintenance.

It is professional, precise, permanently updated and intuitive program. It has no limited number of users, secure and has constant support from the central office in Germany.

The software has four modules (deZem):

- deZemVis: it allows the visualization and analysis of energy and environmental data.
- deZemAd: administration of alarms, measurements, metadata and users of the energy control system.
- deZemReport: it allows to take reports of energy and environmental data.
- deZemCap: it is a manual reading application. It allows selecting a meter from the list and modifying the digits. At the moment, this functionality is not available.

Another feature that it offers and is very useful is the possibility of creating dashboards. A dashboard is a graphic representation of the main indicators (KPI) that intervenes in the achievement of the business objectives, and it is aimed at making decisions to optimize the strategy of the company.

For the project, one has been created like the one shown below:

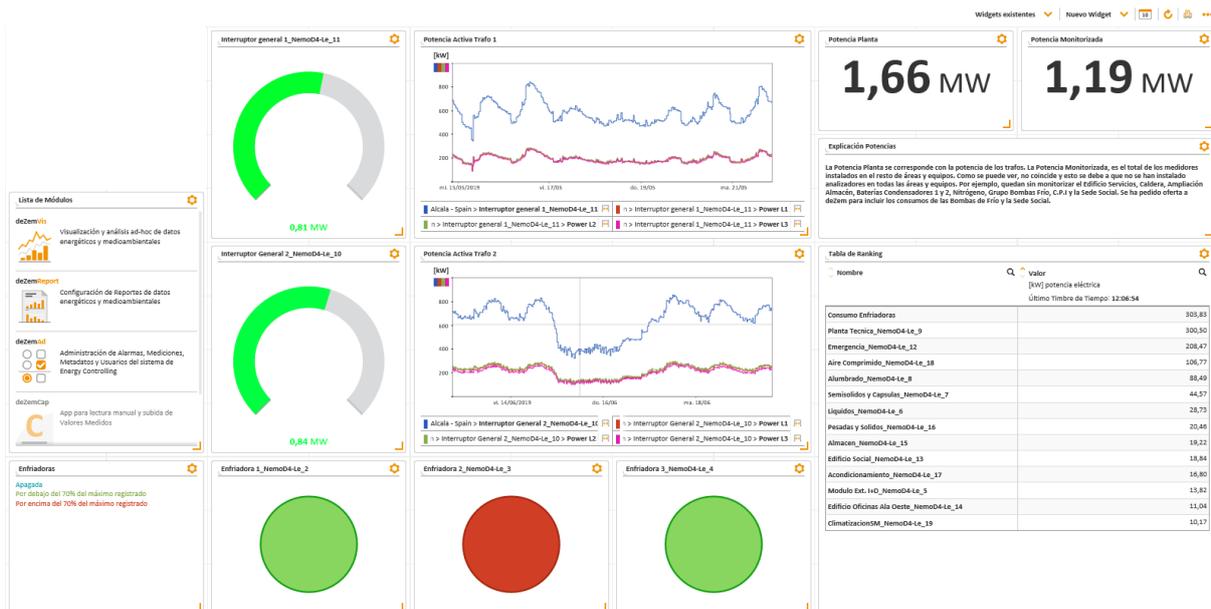


Figure 22. deZem dashboard

In this dashboard of Figure 22, it can be seen, for example, the level of use of the transformers and their corresponding graphs. Also the level of use of the Enfriadoras through some dot widgets. Visually, it can be observed if the Enfriadoras are not working, if they are running below 70% of their capacity and if they are over it. It also includes a legend with this information. It also shows the total power of the plant and of this which is currently monitored. Finally, there is a ranking where they appear ordered from higher power to lower study circuits.

These parameters that are included are those that have been used at the time of the analysis. By having them in the dashboard, they are displayed as soon as you the software is open, so there

is no need to calculate them or look for them. So, this functionality saves time. Nevertheless, this is a simple example of what can be done with the software.

Finally, a user manual is attached to the end of the memory in APPENDIX C: deZem Software Manual. In it, not only each functionality is explained in further detail but also, how to create graphs, virtual points of measure and how to configure the system are included.

## 4. ENERGY CONSUMPTION ANALYSIS

The study plant has a medium voltage power supply that serves the entire installation through a transformation center. This has two 1600 KVA transformers as it can be seen in the Plan 6. Specifically, the Transformador 1 supplies the Edificio Social, Módulo Externo de I+D, Planta Técnica, Almacén and the extension of this, Edificio de Servicios, the three Enfriadoras, Caldera, Oficinas Ala Oeste, Batería de condensador 1 and Nitrógeno. Transformador 2 serves the area of Pesadas y sólidos, Líquidos, Semisólidos y cápsulas, Acondicionamiento, Alumbrado, Grupo de bombas de frío, Aire comprimido, Grupo electrógeno, CPI, Batería de condensador 2, Cuadro de clima de semisólidos, Sede social y Planta piloto.

### 4.1. BACKGROUND

As previously mentioned, energy saving is something that every company must keep in mind. Before this project, the plant did not have any monitoring system, which made it difficult to implement measures to reduce cost and energy. However, by using the excel sheet available, a first and general analysis could be done.

#### 4.1.1. ANALYSIS

Energetically, the main consumptions presented by the plant were electricity, gas, water and compressed air, especially the first two. As previously mentioned, due to the time limitation of the project, only electricity was studied.

Here, the electric bills and the kWh consumed from January to December of the eight past years are presented in Table 11 and Table 12:

**Table 11. Monthly electricity cost**

	€								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Jan</b>	67.780	64.032	76.006	71.171	53.235	70.177	56.222	81.121	69.754
<b>Feb</b>	75.236	71.175	75.301	67.102	42.698	65.924	54.081	63.384	68.480
<b>Mar</b>	62.900	56.828	59.089	50.779	45.546	62.399	48.242	60.049	56.230
<b>Apr</b>	52.714	47.798	49.780	53.657	43.659	62.588	44.997	55.166	58.490
<b>May</b>	49.297	54.995	54.404	54.595	57.617	65.527	49.974	65.370	75.385
<b>Jun</b>	74.471	75.901	75.532	78.759	71.223	89.503	86.244	91.374	98.179
<b>Jul</b>	95.180	85.557	97.220	111.073	88.312	116.037	91.982	98.029	121.545
<b>Aug</b>	36.358	34.156	44.008	59.146	67.018	70.366	60.225	60.759	83.692
<b>Sep</b>	59.095	59.423	63.874	70.028	76.093	71.892	64.885	70.587	101.417
<b>Oct</b>	44.766	45.915	58.671	66.218	78.024	62.166	65.088	75.756	86.037
<b>Nov</b>	48.409	52.272	55.258	59.240	63.762	65.124	63.400	67.655	73.014
<b>Dec</b>	53.143	60.444	59.817	55.162	63.329	64.910	66.911	69.387	67.876
<b>TOTAL</b>	<b>719.349</b>	<b>708.497</b>	<b>768.961</b>	<b>796.929</b>	<b>750.516</b>	<b>866.614</b>	<b>752.252</b>	<b>858.636</b>	<b>960.098</b>

Table 12. Monthly electricity consumption

	kWh									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	
<b>Jan</b>	575.339	581.690	615.864	549.129	567.090	614.890	580.509	606.174	667.480	
<b>Feb</b>	626.957	620.497	615.968	512.757	578.218	621.873	648.125	582.175	633.363	
<b>Mar</b>	688.108	668.515	626.862	525.284	673.305	695.074	694.887	704.058	681.811	
<b>Apr</b>	701.119	633.015	555.007	611.524	659.368	686.309	726.073	656.241	729.103	
<b>May</b>	721.153	739.726	607.611	624.228	704.782	736.941	772.018	771.622	809.400	
<b>Jun</b>	762.021	732.332	658.958	699.598	712.827	795.216	938.162	905.270	903.774	
<b>Jul</b>	850.507	746.092	742.219	833.541	858.319	931.939	957.719	961.846	1.029.103	
<b>Aug</b>	571.212	554.250	564.626	725.387	776.118	707.801	770.034	714.980	829.504	
<b>Sep</b>	765.453	695.565	671.000	747.958	741.440	733.531	755.633	799.698	905.007	
<b>Oct</b>	654.008	614.761	670.987	731.474	826.917	653.191	673.872	795.119	838.156	
<b>Nov</b>	628.735	614.734	565.779	606.713	704.135	648.188	604.036	645.220	699.294	
<b>Dec</b>	511.463	546.268	476.231	477.485	587.566	554.985	550.558	606.363	574.601	
<b>TOTAL</b>	<b>8.056.075</b>	<b>7.747.445</b>	<b>7.371.112</b>	<b>7.645.078</b>	<b>8.390.085</b>	<b>8.379.938</b>	<b>8.671.626</b>	<b>8.748.766</b>	<b>9.300.596</b>	

In order to see the differences between years and between months clearer, the data collected in Table 11 and Table 12 has been represented in the following graphs:

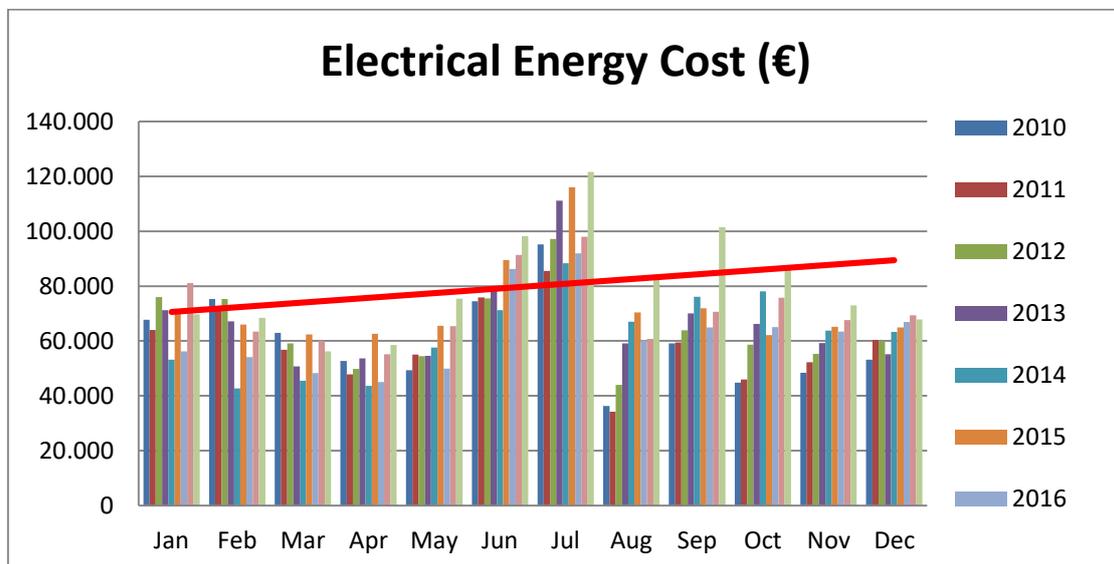


Figure 23. Electrical Energy Cost

In Figure 23, it can be seen that as the market price of electricity increase and also, the plant activity, the site has paid more over the years as it was expected and can be observed in the tendency line. However, as it will be explained later, the plant has already implemented some saving measures that have helped them making a more efficient use of the electricity and therefore, during some months, the cost the company has paid is not that different in comparison with other periods of previous years. On the other hand, a clear trend of cost is observed throughout the different months of the year that will also be later explain together with the consumption. But during the months of June and July, the site pays more than the rest of year because more energy is required to make it work. It is noticeable the peak of September 2018.

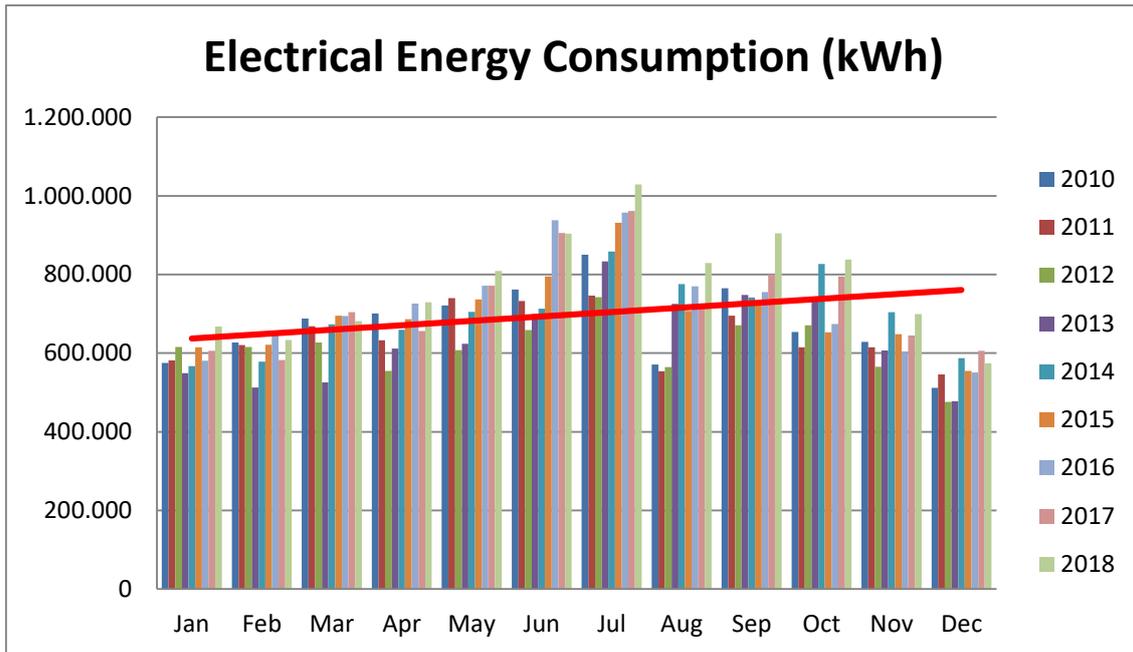


Figure 24. Electrical energy consumption

In Figure 24, two clear things are observed. On the one hand, it can be seen how, in general, the consumption of electricity has increased over the past eight years. On the other hand, a clear trend of consumption is observed throughout the different months of the year, depending on the different operating rhythms of the plant. For example, during the months of December and January (Christmas season), the consumption of the plant is reduced. This is due to the manufacturing stops that take place on those days. However, demand peaks in the months of June and especially July are remarkable. This is due to the increase in the production and in large part to the air conditioning. In the month of August, when there are also stops, consumption by air conditioning is not as high as in the previous months. Besides, the more energy is required, the more money the plant should pay and that correspond to what it can be seen in Figure 23.

#### 4.1.2. PREVIOUS SAVING MEASURES

Attending to this tendency of increase in energy consumption and therefore cost, the plant has carried out different actions to try to reduce its bills, consumption and to be more energy efficient.

In 2010, the possibility of building a cogeneration plant was studied. The main advantages offered by this type of plants were the increase in efficiency of energy conversion and use, the reduction of emissions to the atmospheric environment, cost savings, improvement of general and local supply security.

An economic viability study was carried out to analyse the benefits that this project would imply. On the one hand, the economic savings of the installation were verified. Own calculations of profitability were also made to verify the rapid recovery of the investment.

Two alternatives were raised. The first option consisted of a natural gas cogeneration plant, with an electric power of 1000 kWe and an absorption of 0 kWt. The second consisted of a natural gas trigeneration plant, with an electric power of 1000 kWe and an absorption of 350 kWt. Building a cogeneration plant would involve an investment of approximately € 920,000 that would be recovered in 4 and half years.

However, the project was rejected not only due to the great investment but also to the regulatory changes that the Government ruled by repealing Royal Decree 661/2007 which regulated the production of electricity under the special regime and abolished incentives for new facilities under temporary regime with Royal Decree-Law 1/2012.

In 2016, audits were also made in which they proposed a series of changes. Examples of such changes are: luminaire changes of different areas, the implementation of enthalpic recuperators of the previous phase of air treatment in ATU or the implementation of HVAC control systems in ATU in the warehouse area and silo to improve the rationalized use of the installation,

This proposal included a combination of methods that would allow savings between 15% and 30% in energy costs for HVAC:

- Set the temperature set point according to the occupation.
- Adapt heating or cooling power according to real needs of the building.
- Raise the temperature to the comfortable level when the presence of occupants.
- Adapt ventilation flow according to occupation or level of contamination of the internal air.
- Recover heating energy or cooling of extracted air.

Other measures presented were the renewal of the fleet, the improvements in the primary and secondary circuits of cold water, reduction of light flow in streetlights, fractionation of power compressors and the installation of frequency variators.

Some of these measures were feasible to install while others implied a small saving compared to the investment and large amortization period. So, part of the luminaire was changed, control systems in ATUs and frequency variators were considered.

Therefore, those measures implemented had a positive effect on OpEx at the time. Nevertheless, energy management is a process that must be updated continuously. As it can be seen in the graphs above, both the consumption and the cost has increased in the last few years despite the previous actions.

However, since the site did not have a proper monitoring system it was difficult to identify where to take any other actions.

## 4.2. DEZEM ANALYSIS

Here, the analysis that has been carried out with the deZem software is explained. First, there is the description of how the analysis has been carried out. Next, the study of each of the areas and those one which consume the most. Finally, the possible measures to be implemented before the results observed in the analysis.

### 4.2.1. METHODOLOGY

As previously mentioned, efficiency improvements had already been carried out at the plant, so the usual and recurrent measures such as frequency converters, capacitor banks or change to LED luminaires were already implemented. Therefore, in order to improve energy performance, it was necessary to think of more specific measures and locate processes or equipment where there would be room for improvement. However, for it, more data that the one collected for two months was required. So, it was decided that the analysis would try to identify points where the plant could perform more efficient.

The installation of the system began on April 2, but it was not until the 11th that it was correctly connected and transmitting data to the software, with the exception of the devices that measure the consumption of Alumbrado and Pesadas y Sólidos. These two devices came badly configured from Germany, so they showed erroneous data and stops that did not really take place. This problem was solved on May 16.

As the days after the start-up took place Holy Week, the production was stopped on the 18th and 19th of April. What is more, that weekend there was no fourth shift. For this same reason, it was not possible to take average consumption in the first week. However, this allowed us to observe if there were any anomalies or failures in the plant and to draw a baseline in each monitored area.

In the deZem software, all the graphs corresponding to the consumptions of each one of the areas or machines were observed individually from Monday, April 15 to Monday, April 22.

The results expected were to have zero or reduced consumption, but in any case, constant from Thursday to Sunday at least. However, certain consumptions were observed in some of the lines.

For this reason, to see if it was due to specific situations, maintenance or if it was due to peaks that had to be studied, it was decided to analyze the graphs for the period between Monday, April 29 to Monday, May 6, period in which days 1, 2 and 3 were non-working days and production again stopped. In this case, the fourth shift did work during the weekend.

Finally, to try to establish an average consumption in each monitored circuit, two full weeks were chosen to see the normal behavior of the plant.

For these three selected periods, the analysis was done.

### 4.2.2. ANALYSIS

First, the work schedule is specified in order to establish the study criteria in the operation of the company.

**Table 13.** Operating hours

Departments	Operating hours	Hours/day
Laboratory	08:00 a 20:00	12
Warehouse & Production	00:00 a 23:59	24
Offices	08:00 a 18:00	10

As this table shows, there are departments that work all day so there will be areas that have consumption even at dawn. What is more, there is a fourth shift that working during the weekends some weeks.

Then, the consumptions of the areas or equipment monitored in the different periods are presented one by one. Of these, those that suppose a greater consumption have been selected and have been analyzed in greater depth.

#### *Planta Tecnica*

The analyzer 9 is located at the exit 3 of the LVGS of the Plan 6, which corresponds to the one-line diagram number 7. The main consumption that can be seen in this are: air conditioning with a power of 282 kW, water treatment with 60 kW and the CVC review line 3.

Here, the consumption of the first study period two days of holidays:



**Figure 25.** Planta Tecnica consumption 15/04 - 22/04

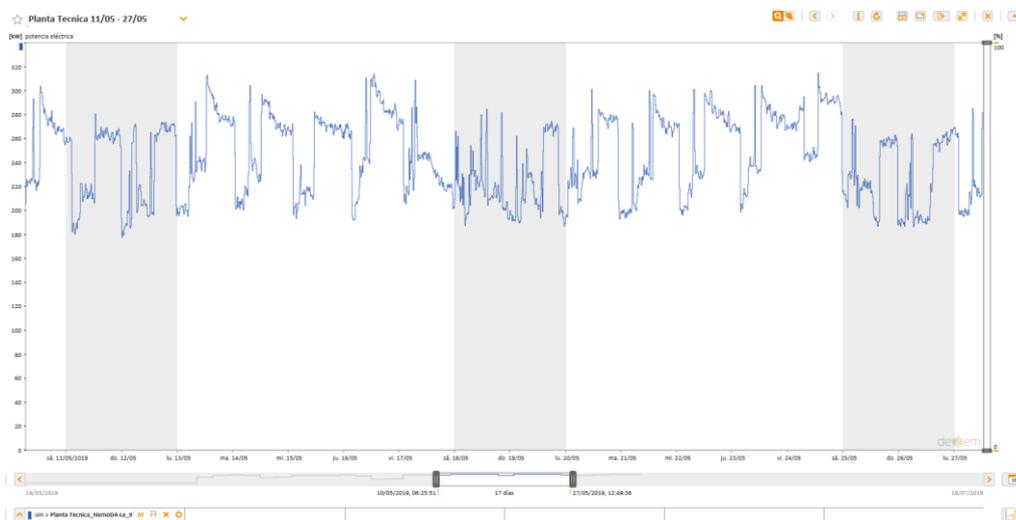
At first there is no clear pattern of electricity consumption. However, in Figure 25 there is a permanent consumption of 145 kW. Nevertheless, it drops to 100 kW in Figure 25.



**Figure 26.** Planta Técnica consumption 29/04 - 6/05

In both figures, the permanent consumption during the usual working days is 200 kW and the consumption during the day is around 240 kW. It has also been observed that the plant returns to its normal operation on Sunday afternoon.

But this would only be for periods of work stoppages due to bank holidays. Because if we observe two complete weeks of operation, a clear baseline of 190 is observed that is reached at dawn.



**Figure 27.** Planta Técnica consumption

Here a certain pattern is identified. There are usually two peaks: about 3 in the morning and another between 8 and 9. In addition, in the morning, it has an average consumption of 200 and as of noon, the power demanded for the plant rises to 270 kW. However, this pattern presents some irregularities.

As previously mentioned, the average weekly consumption is 240 kW and on weekends it is slightly reduced, although it usually follows the same pattern as during the week.

With regard to the air conditioning panel, the ATUs are working permanently and more now with the EMS project (Environmental Monitoring System). It is expected that the ATUs will work 24 hours. The water box has automatic works depending on the demand of the plant. Also about 3 in the morning, osmosis stops usually occur causing the mentioned peak. What's more, every 4 hours the loops are raised to 50 Hz for 10 minutes to clean the tanks. With respect to the reviewer, it may happen that they do not turn them off which should be solved by creating awareness among the employees about the importance of turning off every machine which is not going to be used.

### Enfriadoras

There are three analyzers (2, 3, and 4) on the exits 6, 7 and 8 of the LVGS. Each of the Enfriadoras can support a maximum power of 235 kW.

The Enfriadoras calculate the % power demanded by themselves, although the connection of these is done manually by the employees of the plant. Every 2 hours, a revision of the temperature takes place and in case that it is high, an Enfriadora is connected. There is always at least one supplying the plant.

In the first study period, it is seen that from Thursday on, only Enfriadora 1 is working. These days there was no good weather so no ATUs were needed working to maintain the temperatures in some parts of the plant such as the warehouse that has the set point. So, it seems that it is working correctly.



**Figure 28.** Enfriadoras consumption 15/04 - 22/04

There is no pattern in terms of schedule, but it does in work performance. It is seen that while one of the Enfriadoras requires more than half of its maximum power (235kW), that is, more than 120 kW, there are two Enfriadoras running. However, when the power demanded of the one that is contributing with more power, it drops to 120, the other Enfriadora that is supporting it is disconnected.

The sudden disconnections are mainly due to alarms that jump into the system like flow faults or problems in the evaporator. But these alarms are controlled.

However, on the bank holidays at the beginning of May, it was hot. Therefore, ATUs were probably needed to maintain temperatures in certain areas of the plant. Besides there were people working in the fourth turn. Hence, during the holidays two Enfriadoras were working. During the weekend, only Enfriadora 2 was working giving an average power of 120 kW.



**Figure 29.** Enfriadoras consumption 29/04 - 06/05

However, in this week it can be seen certain irregularities and inefficiencies. The first thing that must be clarified is that each one can supply up to 235 kW, having two of them or even the three operating at the same time when one still has room to give more power, results in an inefficient operation. At a minimum, when there are two running, both should be supply half of their maximum power. Therefore, the Enfriadoras here are not functioning efficiently.

In the last study period, it can be seen how the plant demands an average power of 200 kW, which increases during working hours and is reduced to the base line during the night at 150 kW.



**Figure 30.** Enfriadoras consumption 06/05 - 20/05

Again, it can be observed that certain irregularities happen such as the connection of a third Enfriadora when the other two have capacity margin.

In the three figures above, the Enfriadora 1 (blue) is providing power practically throughout the whole study period although it only has a base consumption of 20 kW.

The Enfriadora 2 (red) and 3 (green) are the ones that usually supply most of the power to the plant alternately or when there is high demand, working at the same time. Although the 3 is the one that is usually in constant operation, more than the 2.

The Enfriadora 3 (green) seems to come into operation about 10 in the morning and reduces at 10 in the night. Around 2-3 in the afternoon, it has the peak consumption. Baseline during the week of 120 kW when it is in operation.

Therefore, it is necessary to review the operating modes and turning on/off of the Enfriadoras to avoid that they are operating unnecessarily, spending more energy and therefore, generating a greater economic expense.

**Modulo exterior I+D**

The analyzer 5 is located at output 11 of the LVGS, which corresponds to the single-line diagram numbers 8 but this have little data on them. Possible consumption could be due to dryers, internal equipment, climate or reactors. Also, a water plant for R&D.

In this first period, the following consumption pattern is identified. At night and during the weekends, the plant consumes the base line of 9-10 kW. In contrast, weekdays, consumption increases between 6 in the morning and 5.30 in the afternoon, being the consumption in this case of 12 kW.



**Figure 31.** Modulo Ext. I+D consumption 15/04 - 22/04

In the next study period shown in Figure 32, the same pattern is recognized again. However, on Wednesday that was holiday, there is a certain increase in consumption. This may be because they have come to work.



Figure 32. Modulo Ext. I+D consumption 29/04 - 6/05

If we now see two full weeks, the pattern mentioned previously continues to be identified:



Figure 33. Modulo Ext. I+D consumption 06/05 – 20/05

However, this Figure 33 shows an increase of 5 kW in the baseline. The power increases again in the same hours before and the average consumption the same plus 5 kW.

This behavior is repeated throughout the analysis period. It may be due to the use of certain equipment on this area at this time. Therefore, a better control of the turn off of the equipment should be done.

### Líquidos

The analyzer 6 is located at output 14 of the LVGS, which corresponds to the single-line diagram number 9. The main consumptions that can be seen in this are: LI-005/4 15 kW

(injectable preparation), LI-006 55 kW (autoclave), LI-007/1 47 kW (bottle washing), LI-014/2 15 kW (gastro preparation), Technical Plant 15 kW and LI-018 15 kW (SAS).

Next, the following graphs are commented. Since a similar behavior is observed in the three of them, a general comment is made of the following three periods studied:



**Figure 34.** Líquidos consumption 15/04 - 22/04



**Figure 35.** Líquidos consumption 29/04 - 6/05



**Figure 36.** Líquidos consumption 6/05 - 20/05

In all periods of study, it can be seen a very similar pattern of consumption that starts around 7 in the morning and ends at 8 in the afternoon, working hours. However, it does not seem that this happens 5 days a week. It seems that one day of the week, it does not demand. It may be that one day a week they do not produce. The fact that during the week, the base line cannot be reached at night, may be due to leaving machines on.

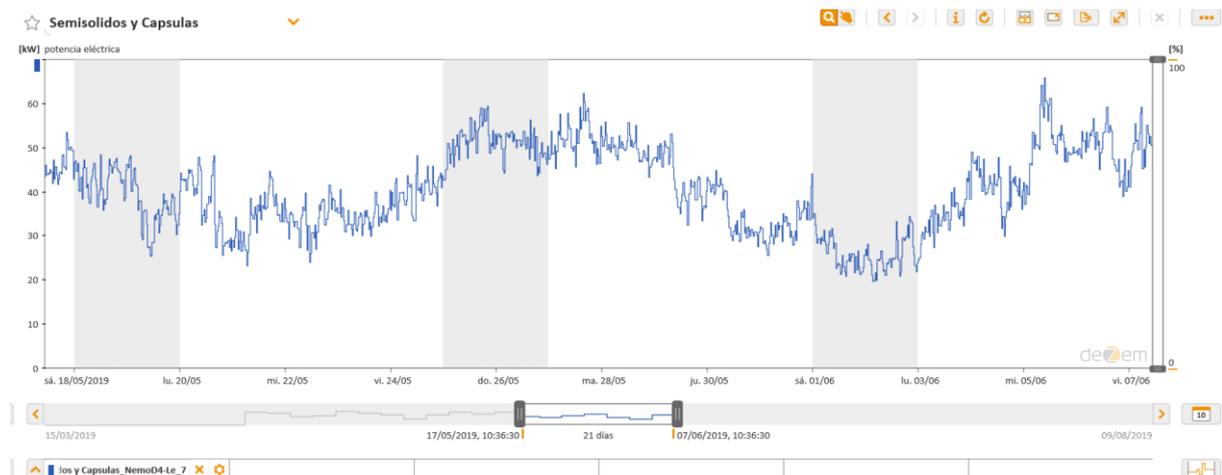
It has a base line of 3,5 - 5 kW that permanently consume the equipment resistors. The average consumption is around 30 kW.

On weekends, there is hardly any consumption, regardless of whether they follow holidays or normal days.

### *Semisólidos y Capsulas*

The analyzer 7 measures the exit 15 of the LVGS, which corresponds to the single-line diagram number 10. The main consumptions are in the following rooms: SM-022 70 kW (upper encapsulated floor), SM-003 16, 5 kW (production) and SM-002 11 kW.

This meter is one of those involved in the problem of IP matching. For this reason, they begin to consider its consumption from May 16. Then, the consumptions are presented from that date:



**Figure 37.** Semisólidos y Capsulas consumption

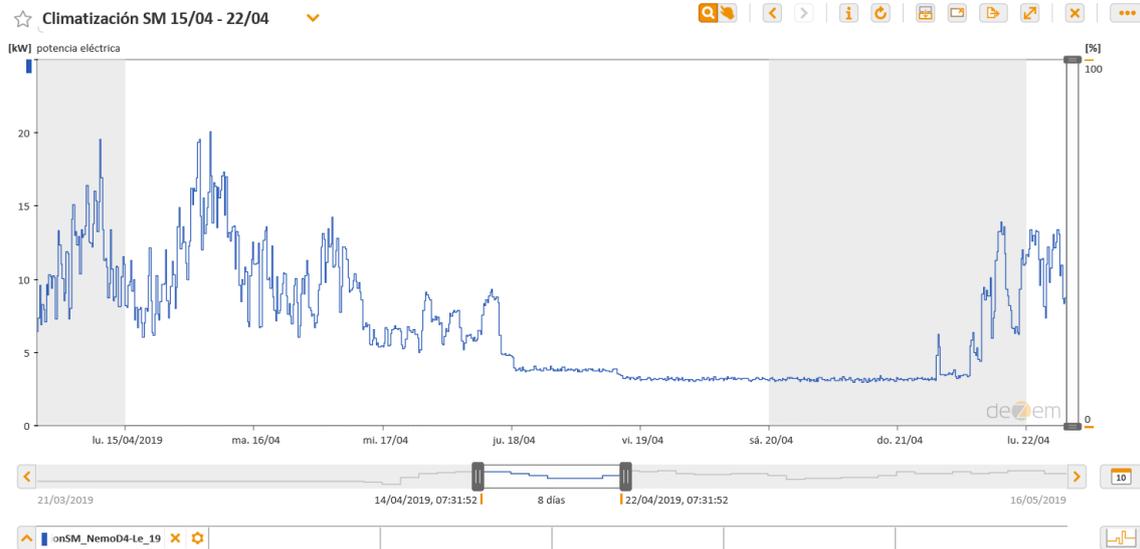
In the Figure 37 it can be seen how the consumption goes up and down in a regular way but it is not a specific time frame. Therefore, there is not a daily pattern to be identified. Consumption goes up for a few days and goes down in others.

A baseline of 30 kW can be established and an average consumption of 40kW.

This pattern might be related with the production that takes place in this areas.

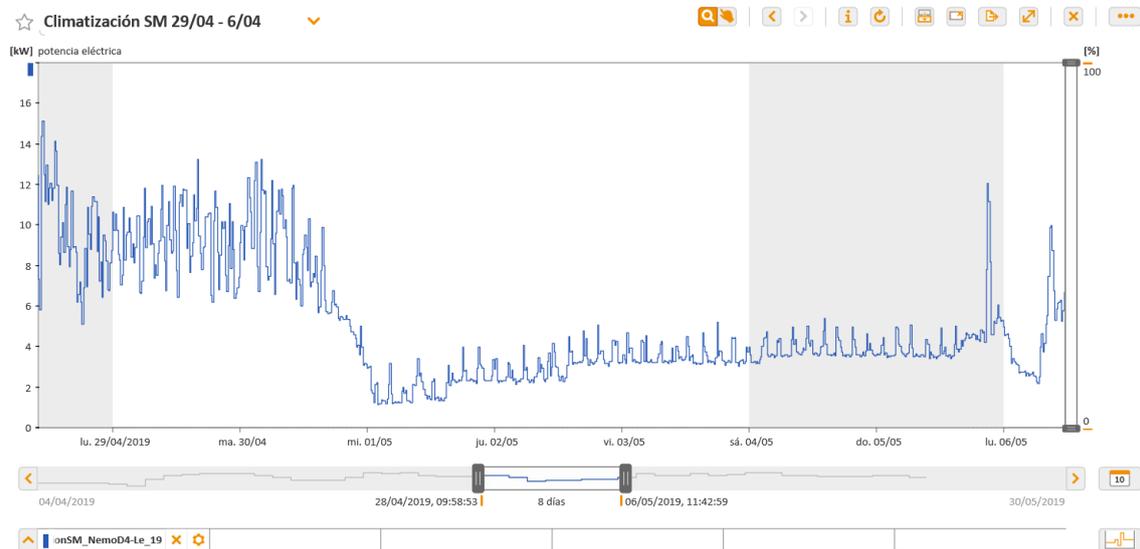
### Clima SM

The analyzer 19 measures the C11 output of the LVGS. Below are the consumptions corresponding to the periods of study:



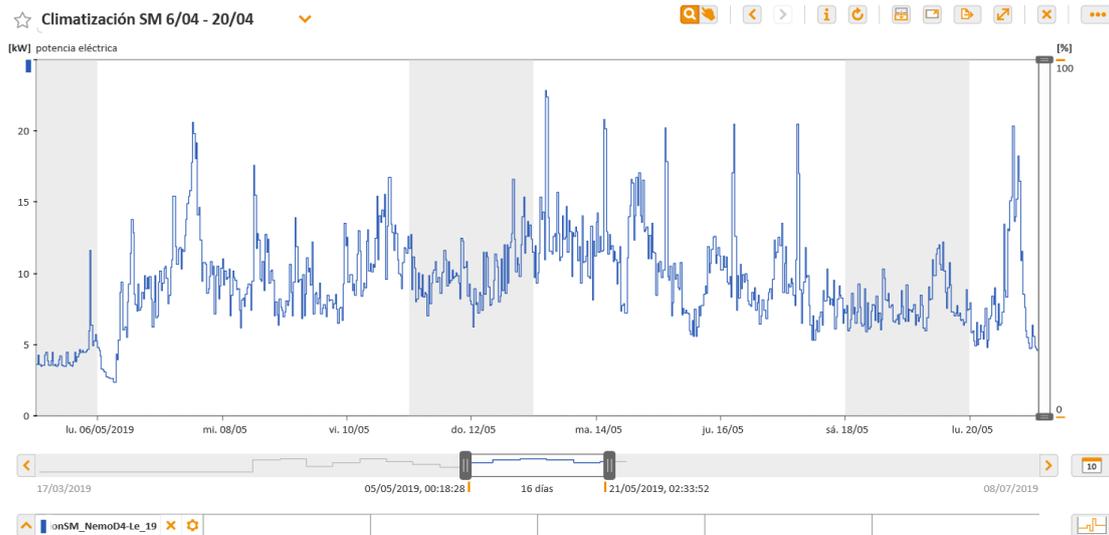
**Figure 38.** Climatización SM consumption 15/04 - 22/04

During the holidays, there is hardly any consumption, only the one corresponding to its base line of 4 kW. However, during the days that work, there are different peaks of consumption but at the same time, about noon. These days it was not too hot so that is why there is such a low consumption. There are 10 kW of average consumption.



**Figure 39.** Climatización SM consumption 29/04 - 06/05

Analyzing the second study period, it seems that there is a more irregular consumption. This may be due to the temperature of those days, higher than the previous period. During the holidays, consumption is around 4 kW again.



**Figure 40.** Climatización SM consumption 06/05 - 20/05

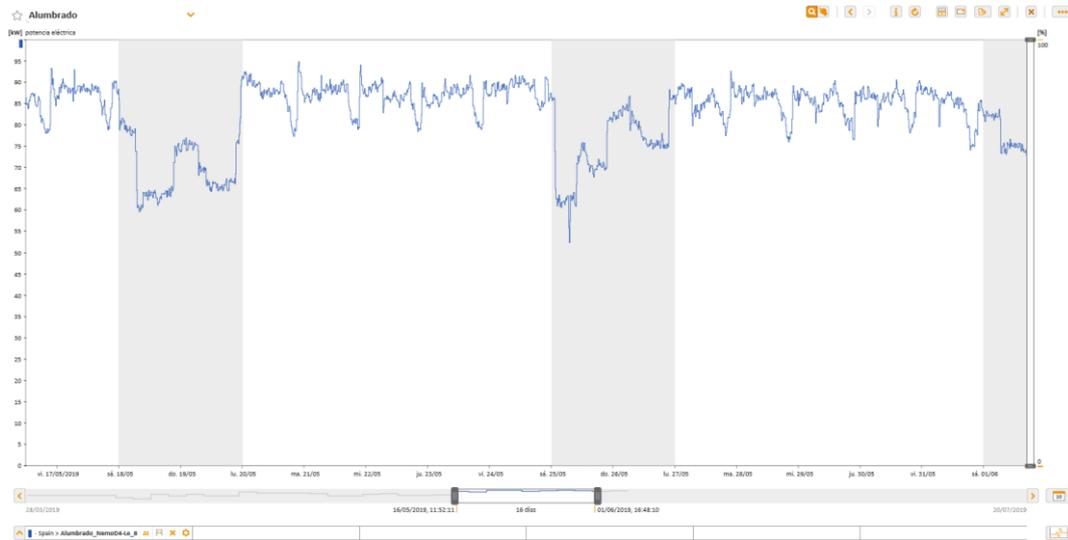
Finally, in the last period, it is difficult to establish a consumption pattern. The peaks seen in the figure now occur at dawn. Although again the average consumption is 10 kW and the baseline in this case is a little higher, around 7 kW.

### **Alumbrado**

The analyzer 8 is located at the exit 17 of the LVGS, which corresponds to the single-line diagram number 11. The main consumptions that can be seen in this are the lighting of the Edificio Social 31.39 kW, of the Almacen 32, 07 kW, Acondicionamiento 31 kW, Pesadas y Solidos 25,73 kW and Semisolidos y Capsulas 25, 62 kW.

The lighting of some areas, on holidays, weekends and nights is null because they are areas where no one work at those times. However, in others such as the warehouse or due to the fourth shift and maintenance, they are constantly running.

As previously mentioned, the consumption of lighting has only been considered from May 16, so for the first two periods there is no data. However, if a normal week of work like the one shown in the following Figure 41 is observed:



**Figure 41.** Alubrado consumption

According to this figure, an average consumption of 87 kW of electrical power can be established during the week, which only reduces by 10 kW between 6 and 10 at night. This should be when the plant workers leave and enter the fourth shift. In any case, this reduction does not correspond to the baseline observed during weekends. This is at 64 kW.

In any case, this baseline is too high considering that from this panel the lighting of the factory is supplied and that, in the absence of workers, it should be considerably reduced. There should only be consumption when people are working or maintenance is carried out.

### *Transformadores 1 y 2*

As expected, both in the first period established as in the second in which stoppages occur in the factory, the power demanded by the plant is reduced as can be seen in the following Figure 42 and Figure 43:

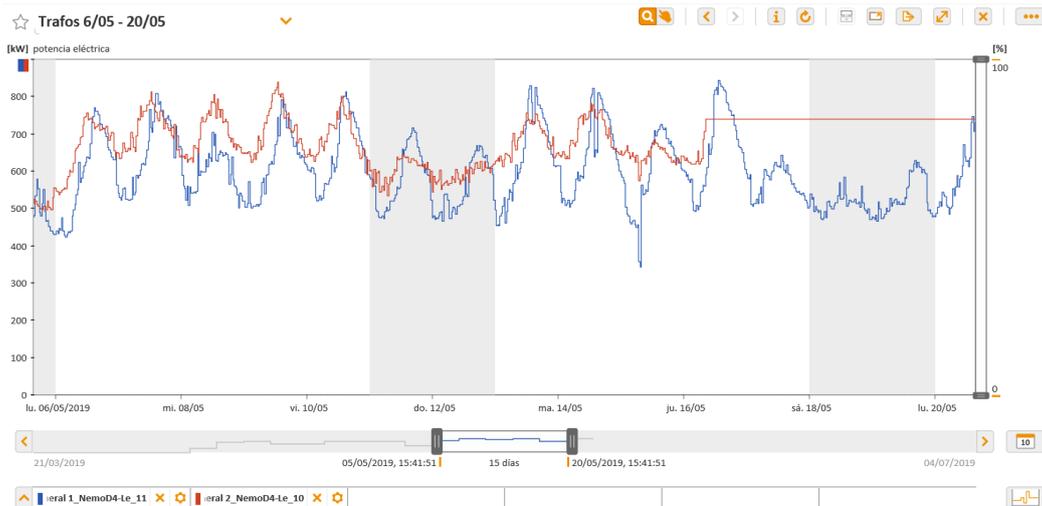


**Figure 42.** Transformadores 1 y 2 consumption 15/04 - 22/04



**Figure 43.** Transformadores 1 y 2 consumption 29/04 - 06/05

During a normal operating week, a fairly defined pattern can be observed in both trades. In general, consumption begins to increase after 7 in the morning, time at which the plant starts to operate. At midday, there is usually a peak demand, around 12 for Trafo 2 and around 3 for Trafo 1. Finally, consumption starts to drop after 8 in the afternoon.



**Figure 44.** Transformadores 1 y 2 consumption 06/05 - 20/05

In this last Figure 44, the fact that the curve of Transformer 2 is flat is due to the fact that the configuration of the analyzer was being checked and did not close well, so it did not measure properly.

It is observed that the Transformer 2 usually works with higher powers more consistently than the Transformer 1. It could be established as a baseline 300 kW for Transformer 1 and 400 kW for Transformer 2. The average consumption is around 520 kW for Trafo 1 and 670 kW for Trafo 2.

Both have the capacity to give more power and seem to work efficiently.

### Edificio social

The analyzer 13 is located at the exit 1 of the LVGS, which corresponds to the single-line diagram number 12. This panel is located in the Edificio Social, where the changing rooms are. From it, they pull mainly electrical outlets, toilets, doors, recorders and the kitchen. However, what is more powerful is the kitchen with 40kW and the 20kVA data process box.

Therefore, this analyzer should not record consumptions or minimums on holidays or weekends. In addition, the weekly consumption should be observed during working hours.

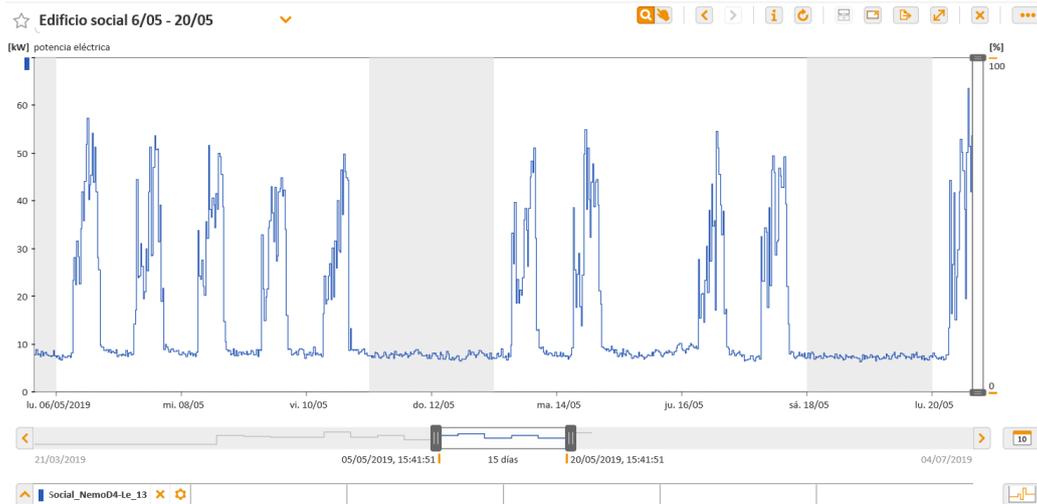
Taking this into account, we proceed with the analysis:



Figure 45. Edificio Social consumption 15/04 - 22/04



Figure 46. Edificio Social consumption 29/04 - 6/05



**Figure 47.** Edificio Social consumption 6/05 - 20/05

Consumptions of the Edificio Social clearly follow the same pattern. The lawsuit starts around 6 in the morning and ends at around 4.30 in the afternoon. There is usually a peak demand around noon.

The base line is at 7.5 kW that is reached at night and during weekends. This is due to the equipment that is permanently connected. The average daily consumption is 38 kW

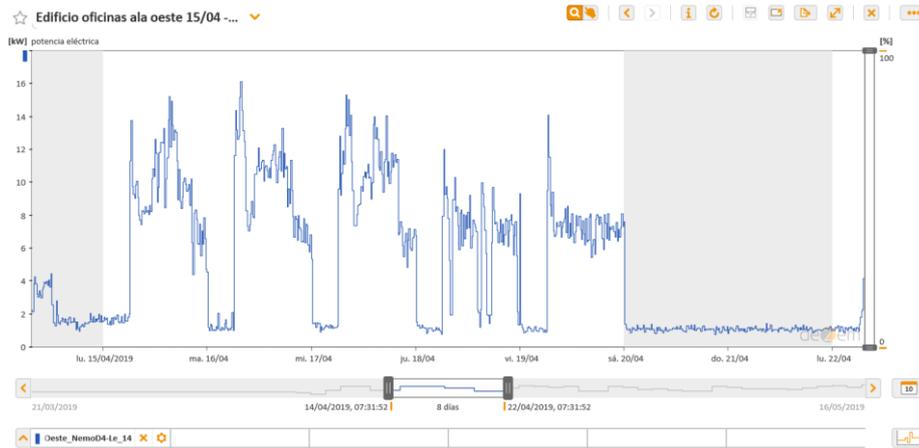
Therefore, no anomaly or inefficiency is identified in this area.

### *Edificio oficinas ala oeste*

The analyzer 14 is located at the exit 2 of the LVGS, which corresponds to the one-line diagram number 13. Looking at the diagrams it seems to supply the pilot plant EL-CS-P1-PIL 173,91 kW, to the office box with 58 kW and to the secondary panel of extension works that there is no data.

The office box is the ground floor of the Headquarters (EL-CS-PB-02) Therefore, the offices of the Value Stream, which corresponds effectively with the offices to the west of the plant. Therefore, on holidays and weekends there can be no consumption of these. But there can be from others.

Knowing this, we proceed to observe the consumption:



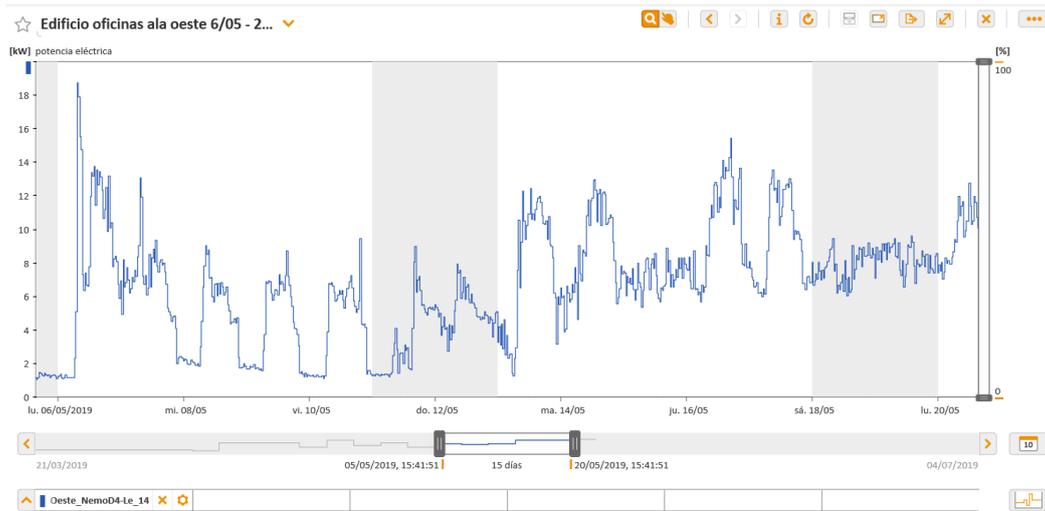
**Figure 48.** Edificio oficinas ala oeste consumption 15/04 - 22/04

It can be seen a consumption baseline of 1 kW that can correspond to printers and scanners that do not turn off. The consumption increases at 6 in the morning and ends at 12 at night, there is a clear pattern. There is an average consumption of 10 kW.



**Figure 49.** Edificio oficinas ala oeste consumption 29/04 - 06/05

The same happens in the week of the holiday banks in May: Monday and Tuesday have the pattern identified, but Wednesday, Thursday and Friday should not have consumptions and the same the weekend. It may be that there has been some maintenance and they have passed by there or that they have gone to work in the extention project.



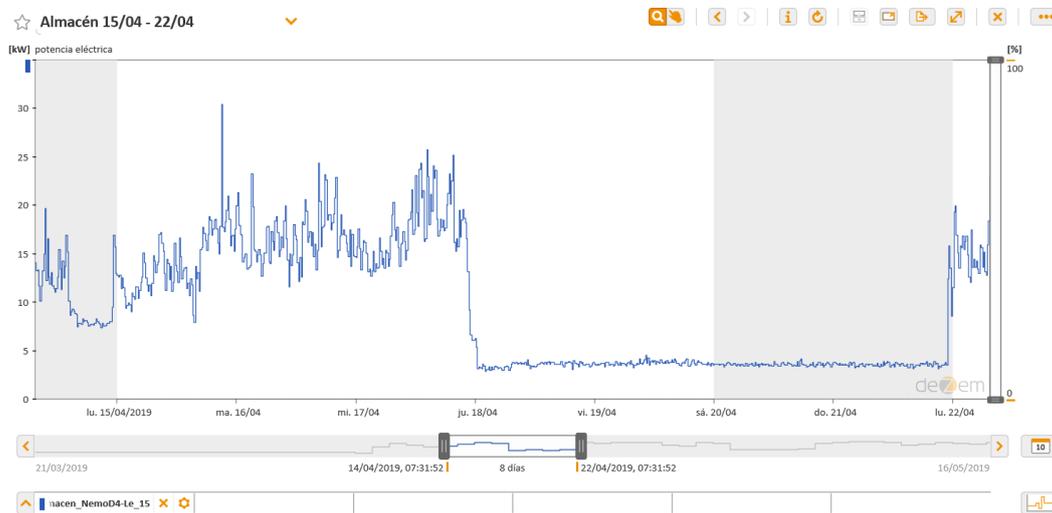
**Figure 50.** Edificio oficinas ala oeste consumption 06/05 - 20/05

However, as of May 6, the pattern changes just as the works begin on the upper floor. Therefore, it may be that this increase is due to works. Even so, it does not suppose excessive consumption.

### Almacén

The analyzer 15 is located at the exit 4 of the LVGS, which corresponds to the one-line diagram number 14. The main consumption is the 200 kW warehouse handling table of the conveyors that are permanently running. There are 130 engines to move the pallets.

If the following Figure 51 and Figure 52 are observed:



**Figure 51.** Almacén consumption 15/04 - 22/04



Figure 52. Almacen consumption 29/04 - 6/05

During working days, it has an average consumption of 17 kW, 24 hours a day, going to 3 kW of baseline on holidays and weekends that follow holidays. However, no consumption pattern is identified. The warehouse is permanently consuming that 17 kW.

In normal working weeks, it is observed that during the week there is a base consumption of 14 kW although on average the plant requires between 16 and 20 kW. On normal weekends, the plant requires an average power of 12 kW and has a base line of 9 kW. However, again, a pattern in terms of hours cannot be established but it can be seen that during the week consumption shows a behavior and the weekend its demand is reduced.

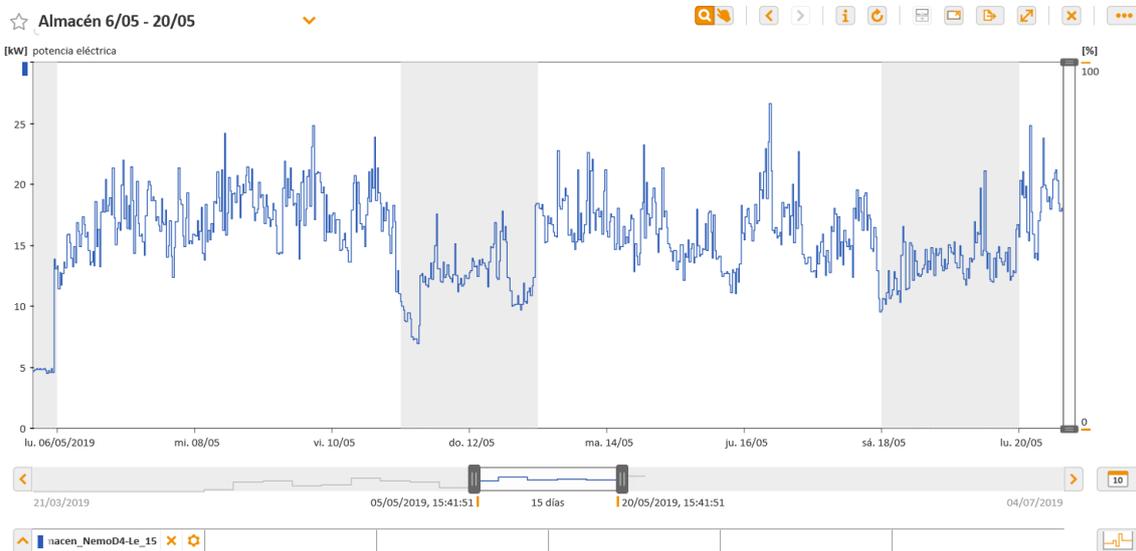


Figure 53. Almacen consumption 6/05 - 20/05

### *Pesadas y sólidos*

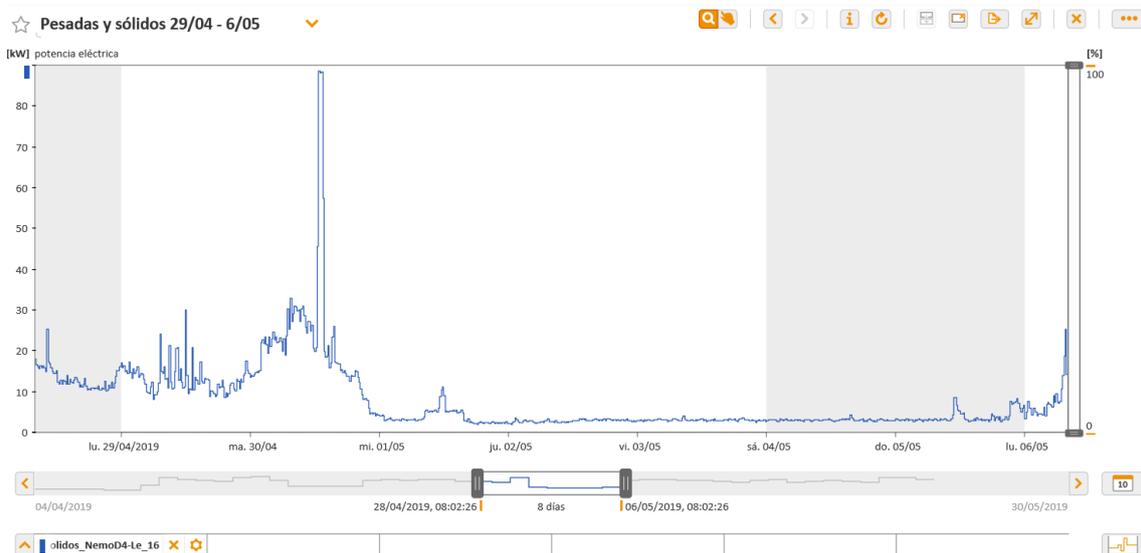
The analyzer 16 is located at the exit 13 of the LVGS, which corresponds to the single-line diagram number 15. The main consumption in this area is that of the machine revision L7 with 10.5 kW.

In the first study period, no pattern is identified although on holidays a baseline of 4 kW is seen. The consumption in the first days is 19 kW on average.



**Figure 54.** Pesadas y Solidos consumption 15/04 - 22/04

In the second period of study, it is observed again what was seen for the first:



The peak of April 30 corresponds to a test that was made to try to solve the problem in the meters of Alumbrado and Semisólidos y Capsulas. The equipment was changed for the one of the Alumbrado for 1 hour.

Finally, studying two full weeks of work, it is seen that consumption follows a pattern. There is a baseline consumption of 10 kW every day. During weekdays, the factory demands around 17 kW. On weekends that do not follow holidays, there is still consumption, although it is reduced with respect to the week, to 13 kW. In general, power increases occur between 6 in the morning and 6 in the afternoon as can be seen below

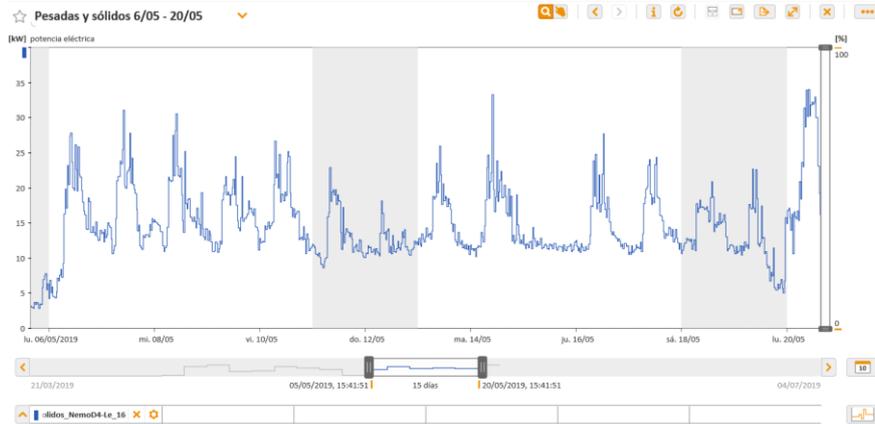


Figure 55. Pesadas y Sólidos consumption 6/05 - 20/05

### Acondicionamiento

Analyzer 17 is located at the exit 16 of the LVGS, which corresponds to the one-line diagram number 16. The main consumptions are the ima and marchesini cartridges of 10 kW, oral lines, ampoules and retractable manual soco 10 kW.

According to Figure 56, the days worked are with constant consumption of 10 kW although between 6 in the morning and 3 in the afternoon, the power increases up to 20 kW. The rest of the hours, it remains the baseline. The consumption of Thursday 18 is due to maintenance. On holidays, consumption is kept at a minimum of 1 kW.



Figure 56. Acondicionamiento consumption 15/04 - 22/04

In the second period, the same thing happens. The power increases from 6 to 3 in the afternoon and at all times there is a base consumption of 10 kW less on holidays than the baseline is 1 kW. On Wednesday there has also been maintenance.

On Sunday at 10 at night consumption begins, but it is not until 6 in the morning of Monday that it starts to be remarkable.



Figure 57. Acondicionamiento consumption 29/04 - 6/05

If now two full weeks of operation are observed:

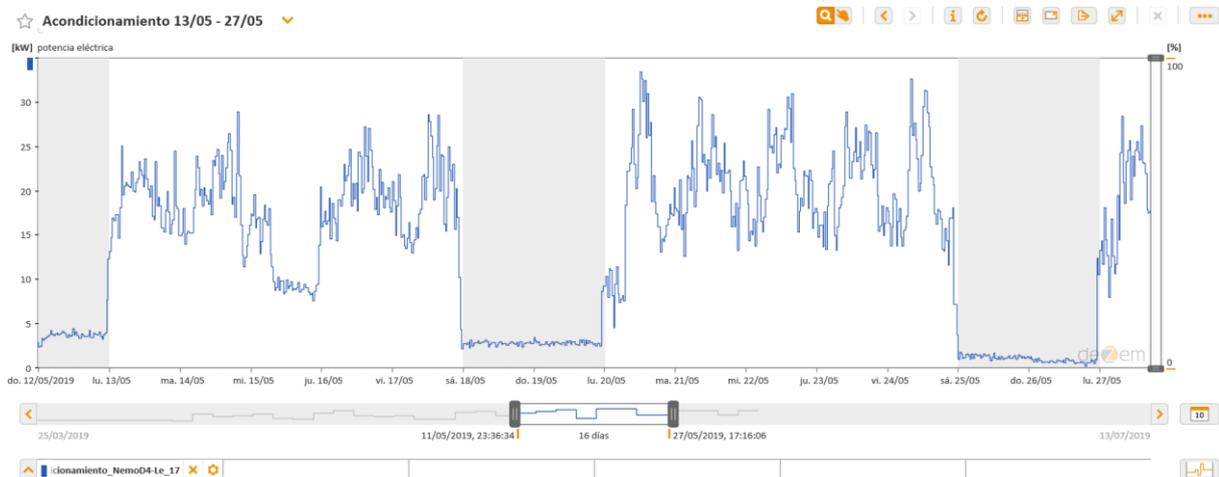


Figure 58. Acondicionamiento 13/05 - 27/05

A permanent consumption of 15 kW is observed throughout the week, although again, as seen in previous weeks, from 6 to 3 there is an increase in power that makes the plant demand 20 kW on average. During the weekends, the baseline is maintained, which increases slightly compared to the holiday weeks at 3 kW.

### Aire Comprimido

The analyzer 18 is located at the exit 19 of the LVGS, which corresponds to the one-line diagram number 17. The main consumptions are 2 pumps, 2 compressors and 2 dryers.

There are devices that connect and disconnect automatically depending on what the plant requires. There is usually one of the compressors working and the other one is supporting if needed. These are 75 and 40 kW respectively.

A permanent consumption of 40 kW is appreciated, and it is clearly seen how the holidays are reduced. However, no clear pattern is observed although large increases in power seem to occur around 6 in the morning when the plant begins to operate. During the first days, there is an average consumption of 65 kW. Demand during the week starts around 6 in the morning and decreases depending on the day. The baseline could be set at 60 kW during the week.



Figure 59. Aire comprimido consumption 15/04 - 22/04

Again, in the second period it is difficult to identify a pattern although on holidays, the consumption is reduced compared to the Monday and Tuesday that were working days. In addition, the power increases start at 6 in the morning and the permanent consumption is 40 kW. Although of average consumption there are 65 kW.

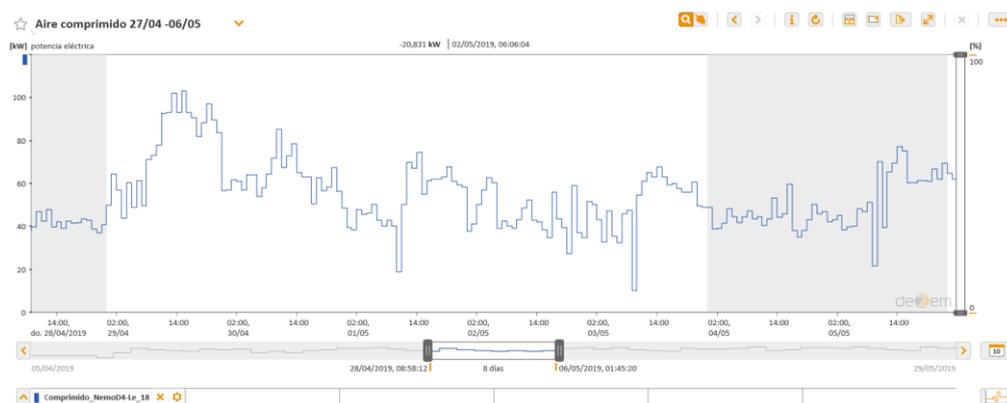


Figure 60. Aire comprimido consumption 27/04 - 6/05

In the last period of study, a more repetitive pattern is observed. During the week there is a permanent consumption of 63 kW and on weekends it drops to 42 kW. However, from Monday to Friday, from 6 the power starts to increase until 6 or 10 o'clock at night depending on the day, having an average consumption of 80 kW. The average consumption during the weekends is reduced to 50 kW.

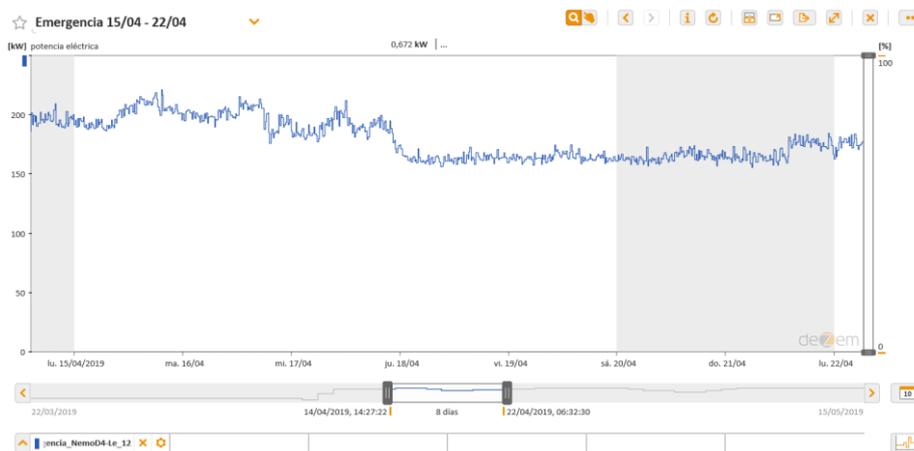


**Figure 61.** Aire comprimido 6/04 - 20/04

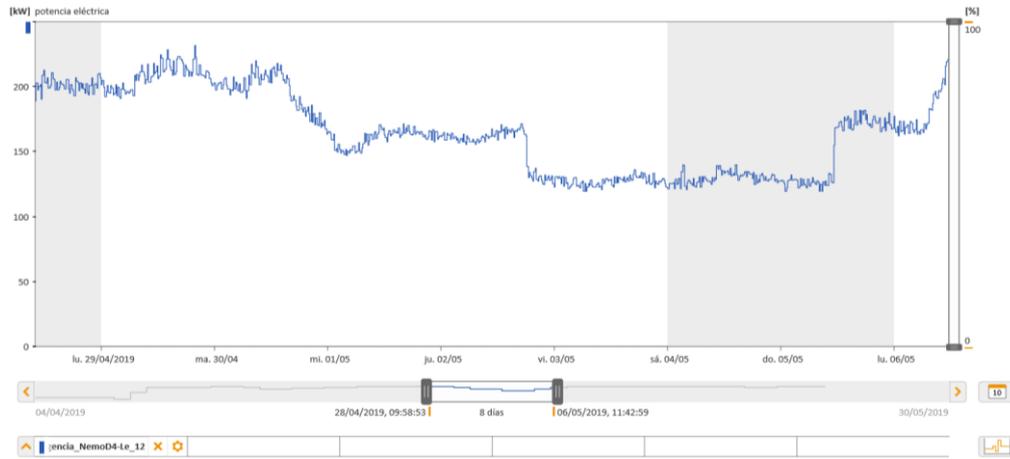
### Emergencia

The analyzer 12 measures the output 20 of the LVGS, which corresponds to the one-line diagram number 18. The main consumptions that can be observed are: the panel for the Sede Social with 77 kW, the Planta Tecnica with 200 kW, Semisolidos y Capsulas with 60 kW and Liquidos with 40 kW.

In holiday weeks, the baseline drops to 160 or even 125 kW as part of the plant is stopped and therefore, less power is needed.

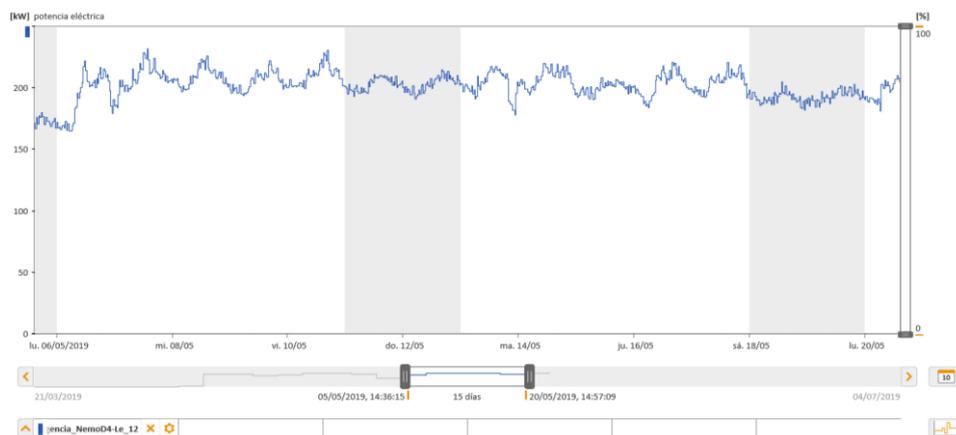


**Figure 62.** Emergencia consumption 15/04 - 22/04



**Figure 63.** Emergencia consumption 29/04 - 06/05

Observing the three defined periods, the plant demands as a base line 180 kW in normal working weeks. The average consumption during the working days, 24 hours, 200 kW, although it seems that it increases early in the morning, decreases in the afternoon and at the end of the day it increases again, although at night it is reduced. During weekends, the power varies between 180 and 200 kW.



**Figure 64.** Emergencia consumption 6/05 - 20/05

### 4.2.3. MAIN CONSUMPTIONS OF THE PHARMACEUTICAL SITE

Currently, the consumption of all areas of the plant is not being monitored: only those that, according to the Plan 6, require more power. Therefore, as we know the total consumption of the plant since there are two analyzers that measure the power for the two transformers and, adding the power for the other 16 circuits, the monitored percentage is obtained. At the moment, we have 71% of the consumption monitored as shown in the following Figure 65:

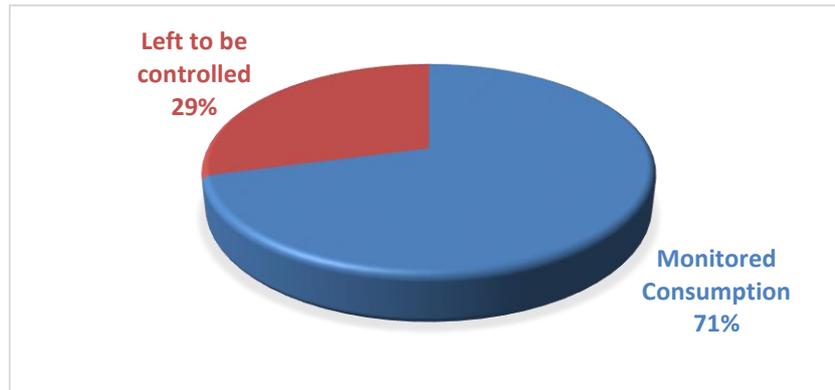


Figure 65. Electric consumption monitored at the moment

This 71% is distributed as follows among the monitored areas:

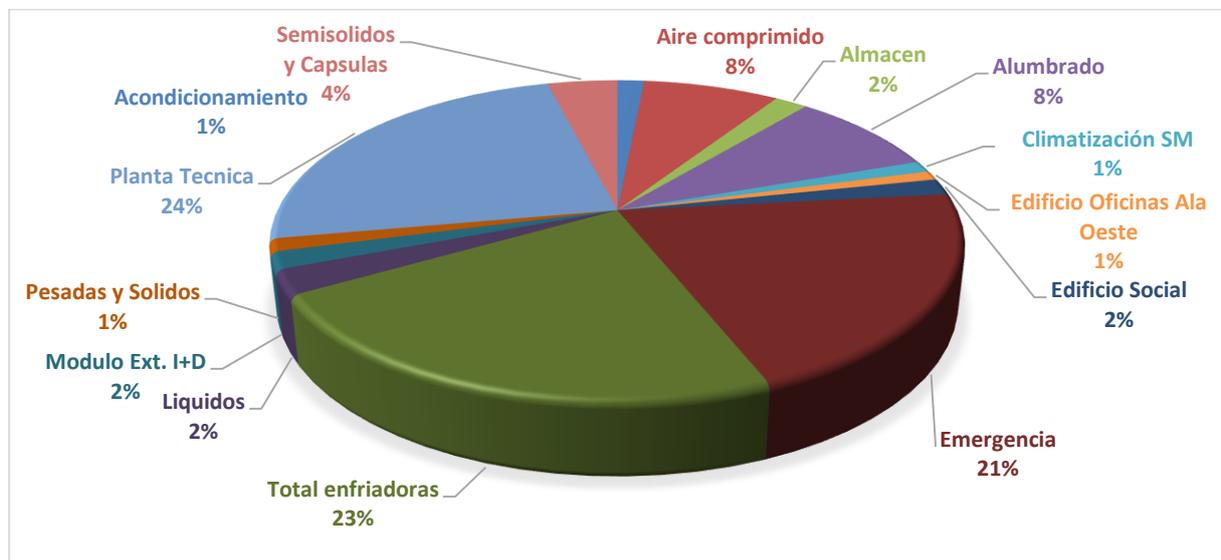


Figure 66. Electric consumption distribution

As it can be seen in Figure 66, the main consumptions of the plant are the Aire comprimido, Alumbrado, and especially Emergencia, Planta tecnica and Enfriadoras. The following Pareto graph in Figure 67 shows these consumptions in MWh:

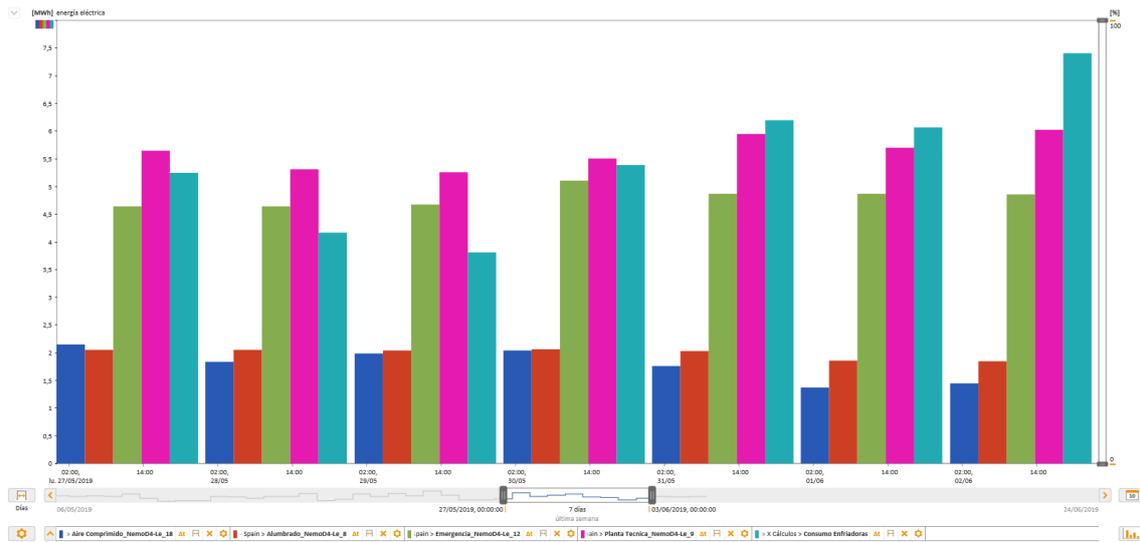


Figure 67. Main consumption of the pharmaceutical plant for a week

Specifically, the consumption that varies the most is the Enfriadoras', as it has been said it depends on the needs of the plant. In addition, the fact that during this week represented the consumption has increased is due to the temperatures that have raised so the Enfriadoras have had to increase their operation to meet the requirements of the plant. The rest of consumption remains stable.

Therefore, when carrying out analysis in greater depth, these areas should be the first to be studied because they are the ones that generate the greatest savings for the plant. In particular, those that are more attractive to implement measures are Aire Comprimido, Alumbrado and Enfriadoras.

The Emergencia circuit is not so interesting to analyze because critical equipment needs electricity from this board so they require a continuous supply and from here it is difficult to obtain points of improvement. On the other hand, the Planta Tecnica has not been considered because it is currently undergoing changes. A new project of EMS (Environmental Management System) is being launched that will make the air conditioning hanging from this board work 24 hour from now, so the data obtained so far is not what will be obtained in the future.

Therefore, from the analysis carried out in each of the previous sections, it has been mainly identified that the Enfriadoras are not working efficiently because in some cases, the three of them are working at the same time when still two have capacity. In addition, it has been seen that the consumption of Alumbrado is quite high throughout the day. Finally, Aire Comprimido supposes sudden ups and downs of power that could be generating excessive consumptions.

#### 4.2.4. SAVING MEASURES

Therefore, a series of theoretical measures to try to reduce the consumption of these areas are proposed.

In the first place, to try to reduce the electrical consumption in compressed air installations the following points could be checked. Most likely, several of them would have already been implemented, tested or analyzed. However, as a reminder or proposal to try to avoid the behaviors of the figures, they are collected here:

- Keep the air generation pressure as low as possible; checking that only the minimum working pressure of the connected equipment is covered.
- Check that the air that is compressed is as cold as possible. It must be taken from the outside and with the outlet facing north. Every 4°C of temperature decrease, the consumption is reduced by 1%.
- Inspect and detect leaks and close underused branches.
- Avoid compressors in deep vacuum for a long time. Use timers so that they only start when there is demand and stop when there is not.
- Check the pressure loss in the air filters. Clean them or replace them if they are dirty.
- Check the correct operation of the water traps. Do not flee. They could also be replaced by automatic systems.
- Analyze the possible recovery of heat in the compressors for other uses.
- Analyze the possibility of zoning the compressed air by demand schedules, by pressure levels or by large specific demands, working at staggered pressures.
- Analyze if the capacity of the air tanks is adequate to their consumption patterns, so that the compressors do not enter loading/unloading frequently with demand points.
- Analyze if there is a part of the factory with demand peaks very different from the rest, and the possibility of having a local compressor for that part.
- Analyze the work pressure. The working pressure directly affects the required power. Higher pressure means higher energy consumption: on average, 8% more energy per 1 bar increase. Increasing the working pressure to compensate for the pressure drop always results in a deterioration of operating costs.
- Analyze the consumption of compressed air to try to find solutions that allow a more balanced load in the pneumatic system. In this way, it will be possible to avoid unnecessary consumption peaks and reduce operating costs.
- Regulation method. With a modern control system, the compressor plant can be optimally operated in different situations, improving security and availability at the same time. The selection of the correct regulation method allows saving energy by reducing the system pressure and optimizing the degree of use of each machine in the installation. At the same time, availability will improve, and the risk of unplanned stops will be reduced.
- Check the quality of the air. The high-quality compressed air reduces the need for maintenance, increases the reliability of the pneumatic system, the control system and the instrumentation, while limiting the wear of pneumatic machines.

On the other hand, for Enfriadoras, a study of operability should be done because, as it has been seen, its current operation is inefficient. In addition, the possibility of using a system with inverter technology could be studied. This regulates the operation of the compressor of the air

conditioning equipment so that they work at a more constant speed, which allows energy savings of up to 40% with respect to equipment that does not use this system. Two-stage compressors could also replace one-stage compressors. What is more, electric compressors could be replaced with gas-powered air compressors.

Finally, for Alumbrado, the plant should try to reduce the identified permanent consumption. 65 kW is excessive if it is not a normal day of work. In addition, at night, there should be a reduction of the demand of the plant because in these hours there are not many workers or maintenance. To do this, as a first step the company must ensure that the lights are off. The plant should create awareness among its employees to save electricity in the lighting so as to make sure lights are off when they are not needed. What is more, they could consider the option of installing presence sensors in those areas that do not have too much continuous traffic such as bathrooms, changing rooms and corridors.

They could also change the luminaires to LED, as they stop working. This would avoid wasting the investment already made, but at the same time, they would promote the change and save both money and energy.

On the other hand, a review of the contracted tariff could be made to try to adjust more to the plant's schedules. Currently the plant has a 6.0 free market tariff. Also, with this tariff, the option of installing a photovoltaic plant could be considered. Although it would take longer to recover the investment than in case of having a 3.X, the price of energy is more economical and in the 25 years of life of the FV, it compensates. A new self-consumption RD came out last month with respect to the FV so it could be a good time for its implementation as permits and procedures have been reduced.

Finally, since many of the offices have windows to the outside of the plant, they should take more advantage of the daylight hours.

## 5. BUDGET AND ESTIMATION STUDY

In this final section, the costs of the project of implementation the energy management system in this initial phase are collected.

In the first place, the costs related to the installation and start-up of the monitoring system are presented. Next, an estimation of the savings that could be achieved in each of these three areas and machines will be made. This saving would be obtained simply by doing a study of these areas and reducing what could be considered phantom consumption due to inefficiencies in the plant. Nevertheless, this is a mere estimation. In order to set firm statements, a further analysis of each part of the plant, processes and machines should be done.

### 5.1. MONITORING SYSTEM IMPLEMENTATION COST

The installation of the monitoring system in the plant to carry out the analysis of consumption has had as costs the following:

- Personnel cost: an intern has been in charge of carrying out the project with the supervision of their superiors for 8 months.
- Monitoring equipment cost: in order to carry out the analysis, it was necessary to install measuring equipment and acquire the deZem software license. The choice of equipment can be found in the section 3.3.1 of the memory. The offers are attached to the end of the document.
- Installation cost: an external company has been responsible for the installation, configuration and support of the measurement equipment.
- Decommissioning the previous equipment cost: as mentioned in the section 3.3.1, in the plant there were previous analyzers that were outdated. As they are not going to be reused, they must be eliminated from the panels. This task will be carried out by the same subcontractor that has done the installation, but they must do it in one of the planned stops in order to cut the current and avoid security problems.

Therefore, all these expenses have been collected in the Table 14. The total initial investment has entailed 21.647,50 € to the pharmaceutical manufacturing plant.

**Table 14.** Actual cost of the monitoring system implementation

COST IN AN ENERGY MANAGEMENT PROJECT			
Costs	Explanation	Responsible	Total
Engineering Costs	Inter with the project	Company	3.600,00 €
Equipment	System, configuration, fees, packing and shipping	deZem	10.654,00 €
Decommissioning	Remove of the previous devices	Third Party	1.605,00 €
Installation	Equipment, including installation material		5.788,50 €
Support	Supervising and training		1.485,89 €
<b>ACTUAL INVERSION</b>			<b>21.647,50 €</b>
Operational Costs	0,15 FTE	Company	4.500,00 €
<b>FUTUR</b>			<b>4.500,00 €</b>

However, from now on, and without taking into account the possible measures to be implemented, a person in the plant should be responsible for performing the relevant analyzes and monitoring. This person should dedicate at least 15% of their working time which, assuming a salary of € 30,000, this will mean € 4,500 a year for the company.

In addition, although the analysis platform does not require maintenance by the plant, it will be necessary to check from time to time that the measurement equipment is in good condition.

Therefore, the types of costs of the management project are those shown below:

**Table 15.** Types of cost in the monitoring system

<b>COST IN AN ENERGY MANAGEMENT PROJECT</b>		
<b>Initial Costs</b>	<b>Operating Expenditures</b>	<b>Decommissioning Costs</b>
Engineering Costs	Operational Costs	Decommissioning
Equipment	Maintenance	
Installation		
Support		

## 5.2. FUTURE COSTS

Implement a monitoring system, allows companies to reduce and control their consumption, but above all, generate economic savings through the efficient performance and implementation of energy saving measures.

Other organizations that have developed similar projects have achieved great savings. Specifically, with the deZem monitoring system, some customers have achieved a cost reduction of between 20% or even 50%.

In this project, a series of saving measures that the plant could implement have been proposed. These actions aim to reduce consumption or at least avoid phantom consumption and consume the established baselines. Some of them requires certain or big investment. However, there are other that simply imply doing a revision of the machines, processes and operating regimes. Hence, they do not need investment.

So, it has been decided to do an economic estimation of what this revision would entail. For it, taking into account the results obtained in the previous analysis, a minimum but feasible percentage has been assumed in each of the main areas.

In Alumbrado, since the permanent consumption seems excessive, it has been assumed a 5% savings the first year with respect to the baseline. This could be achieved by simply controlling the lights on and off and using natural light.

For Aire Comprimido, the same. Since it is observed that there are large ups and downs, it is expected that doing a thorough control of the installation and the machines can save 5% the first year.

Finally, in the Enfriadoras, it has been seen that in general, they are not working at their maximum capacity and that in fact two or even three are working at the same time. This produces inefficiencies. Therefore, it has been thought that if an analysis and control of its operation is made, it could be reduced up to 20 kW the first year which at the end of the year is a great saving.

Assuming that the kWh cost 0,1€, this estimation would imply:

- Alumbrado

$$5\% \text{ of } 64 \text{ kW} = 3,2 \text{ kW}$$

$$3,2 \text{ kW} \times 24 \text{ h/day} \times 365 \text{ days/year} = 28.032 \text{ kWh/year}$$

$$28.032 \text{ kWh/year} \times 0,1\text{€/kWh} = 2.803,20 \text{ €/year}$$

- Aire Comprimido

$$5\% \text{ of } 60 \text{ kW} = 3,0 \text{ kW}$$

$$3,0 \text{ kW} \times 24 \text{ h/day} \times 365 \text{ days/year} = 26.280 \text{ kWh/year}$$

$$26.280 \text{ kWh/year} \times 0,1\text{€/kWh} = 2.628,00 \text{ €/year}$$

- Enfriadoras

$$20 \text{ kW}$$

$$20 \text{ kW} \times 24 \text{ h/day} \times 365 \text{ days/year} = 175.200 \text{ kWh/year}$$

$$175.200 \text{ kWh/year} \times 0,1\text{€/kWh} = 17.520 \text{ €/year}$$

Therefore, a 22.951,20 € save could be reached.



## 6. CONCLUSIONS

The requirements that the market itself imposes, make environmental management in general, and energy in particular, key pieces for the strategic development of companies. What is more, in recent years due to the excessive consumption that society is making of the energies, the need to rationalize the use of energy on a global scale in order to ensure the sustainable future has arisen.

Energy management can be defined as the sum of measures planned and carried out to achieve the objective of using the minimum possible amount of energy while maintaining comfort levels and adequate production levels. It is, therefore, an organized procedure for forecasting and controlling energy consumption, which aims to obtain the highest possible energy efficiency without reducing the level of benefits obtained.

In order to try to make a more efficient use of energy and above all to reduce costs, the pharmaceutical study plant has decided to implement an energy management system, and this is how this project came about.

This had two fundamental objectives: one to define the management system that the plant will use for the certification of ISO 50001 and for this it was necessary to have a consumption monitoring system, the second objective to be achieved. The plant only had Excel sheets where the consumptions of the plant in general were collected. However, to make an analysis of the consumption of the plant, it was insufficient because it was very general.

Therefore, in the first place it was necessary to collect information and become familiar with the processes of the plant. Then, after doing a small market study, the monitoring equipment was chosen and installed.

Regarding the monitoring system, it is necessary to highlight several points. First of all, the search for information turned out to be a bit difficult due to the non-updating or non-existence of certain recorded information. There was no list of equipment by areas, the single-line diagrams were outdated and there were no records of their powers so the decision of where they were installed could have been more accurate if they had had this data. However, the final decision was to monitor areas in general and this is a good way to start in the first phase of implementing a new system. Later on, after a deeper analysis, more specific areas can be controlled.

On the other hand, the deZem system is a simple, safe and flexible solution that will allow the plant to analyze its consumption and see where it can have savings and control its operation. In addition, among its features, there is the possibility to connect the databases of different plants. So globally, the company's central plants will be able to verify the operation of others, which is a competitive advantage over other energy management software.

The drawback of this solution has been that no other plant in Spain has used it or knows it, so it was a completely new system to study. To guide us in its implementation, we contacted other

plants of the same company outside the country. They were guiding us throughout the project but at the end, each plant has different characteristics so the system will also have its variants. In addition, the company charges a license for each point of measurement that you want to collect. At the moment, there is only active power, but if the plant wants to visualize in the platform the reactive power or harmonics, they must pay. Other software offers access to all data recorded by the analyzers so maybe other systems would have been cheaper. Nevertheless, as advantage, other plants from the same company can have access to other sites' data so they are all connected.

The request, reception and start-up of this system took longer than expected. In the first place, because clarification and precision took time due to lack of information. On the other hand, when dealing with foreign suppliers, communication is more complicated and slower. In addition, the installation was not done properly at the beginning, also two of the equipment came badly configured so identifying the problem, and solving it took some weeks. Finally, after carrying out the relevant measures, the system worked, and the analysis could begin.

Initially, when I started the project, I had thought about trying to identify big saving measures. However, the fact of not having a database with which to compare the current behavior of the plant hindered the process. In addition, manu saving measures were already implemented and even the use of renewable energies was studied before but rejecte because of the investment and legislation. For this reason, the new savings measures had to be more specific to processes or machines and because of this, they were more difficult to find. Therefore, only an analysis of the current situation of the plant, possible anomalies, inefficiencies and ghost consumption could be made, and general solutions proposed.

Therefore, the consumption analysis of the monitored areas was carried out. It was decided to study three periods in order to obtain consumption patterns, baselines and average consumption. With this information, we try to identify parts that could be improve or inefficiencies. In some areas, this has been possible. However, in others, the patterns were so irregular that it was difficult to find a reason to justify it. This is because many of the machines in the plant work automatically and turn on or off depending on what the plant requires, and this varies depending on the production and the time of year. Also, some new works are being made to expand the plant. Nevertheless, at least the baseline and average consumption were identified in all of them.

According to the analysis carried out, it has been found that there are certain inefficiencies in the plant. The main consumptions are those of the Alumbrado, Aire Comprimido, Emergencia, Planta Tecnica and Enfriadoras. Especially the consumption of these last three. However, the Emergency circuit is less attractive to study because the consumption does not vary too much and it is necessary to supply electricity to critical equipment. What is more, the Planta Tecnica has not been either taken into account since that part of the site is undergoing changes. Therefore, the data collected does not show its real performance. Therefore, the study has focused on the other consumptions.

To try to reduce these consumptions, a series of general measures were proposed. Although the first thing that the plant should do, would be to do an in-depth study of the machines and processes to find leaks or inefficiencies of operation. Also, raise awareness of the importance of energy savings to the staff of the plant. With these measures, they should already see the savings.

Some estimation has been done, assuming that phantom consumptions are reduced. A realistic and viable percentage has been estimated. It has allowed us to know when the initial investment of the project will be recovered.

Assuming light savings in Alumbrado, Aire comprimido and Enfriadoras, only in the first year 23.000€ could be saved.

Parallel to this implementation, I have become familiar with ISO 50001 and have established some steps that the company must follow to obtain certification. It is clear, then, that this project is only the initial phase of a long and continuous process that must be carried out by the pharmaceutical plant to try to function in the most efficient way possible.

As future steps to be followed are proposed:

- In the first place, the order of two other analyzers has been made for two areas that have not been monitored and that have been considered interesting to control. With this, all the main areas of the plant would be monitored.
- Study what other variables would be interesting to visualize in the software the points that are currently controlled. It might be interesting to include harmonics, reactive or current.
- Once the identified inefficiencies have been corrected, an analysis and study in depth of the equipment and processes that require from each one of the areas controlled should be done. Experts in the machines and processes should carry it out since they are the ones that know and control the regular performance and operation of it. This will seek to find specific measures that apply and improve the efficiency of the plant and involve savings in terms of cost.
- Include other sensors in the data base that are in the plant so they can also be visualize in the software.
- Expand the project to compressed air, gas, water and other energy sources.
- Get the ISO 50001 certification.



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## **8. APPENDIX**

In this final section, the quotations and user manual of the software are attached. In order to make clear and precise references, they are numbered in the following way:

- Appendix A: Offers
- Appendix B: Technical Data Sheets
- Appendix C: Software Manual



**APPENDIX A: Offers**

**Table 16.** Initial offer comparison

	<b>DEZEM</b>				<b>SATEC</b>			
	<b>Units</b>	<b>Price/Unit</b>	<b>Discount</b>	<b>Total Price</b>	<b>Units</b>	<b>Price/Unit</b>	<b>Discount</b>	<b>Total Price</b>
Update/Replacement devices	6,00	320,00	0%	1.920,00	12,00	255,81	0%	3.069,72
New devices	4,00	320,00	0%	1.280,00	8,00	372,09	0%	2.976,72
Current transformers								
iPCX with license for 10 metering tracks	1,00	950,00	0%	950,00	1,00	950,00	0%	950,00
Din rail power supply 24 V	1,00	47,00	0%	47,00	1,00	47,00	0%	47,00
Additional licenses	5,00	70,00	20%	280,00	5,00	70,00	20%	280,00
Accessories ZM8C rail	10,00	37,35	0%	373,50				
Accessories ZM8C cable	1,00	130,00	0%	130,00				
Setup databases & server	6,00	300,00	20%	1.440,00	6,00	300,00	20%	1.440,00
Configuration del hardware	6,00	300,00	20%	1.440,00	6,00	300,00	20%	1.440,00
Man-day partner support	1,00	1.050,00	0%	1.050,00	1,00	1.050,00	0%	1.050,00
Modem	1,00	350,00	0%	350,00	1,00	350,00	0%	350,00
Modem accessories	1,00	43,00	0%	43,00	1,00	43,00	0%	43,00
SIM card	1,00	20,00	0%	20,00	1,00	20,00	0%	20,00
Monthly SIM card contract	12,00	20,00	0%	240,00	12,00	20,00	0%	240,00
<b>TOTAL</b>				<b>9.563,50 €</b>				<b>11.906,44 €</b>

Table 17. ZM8C and ZM8C-P offer without current transformers

<b>HARDWARE</b>	<b>DEZEM</b>			
	<b>Units</b>	<b>Price/Unit</b>	<b>Discount</b>	<b>Total Price</b>
iPCX with license for 10 metering tracks	1	950,00	0%	950,00
Additional licenses	5	70,00	20%	280,00
Din rail power supply 24 V	1	47,00	0%	47,00
Modem	1	350,00	0%	350,00
Accessories	1	43,00	0%	43,00
SIM Card	1	20,00	0%	20,00
Monthly SIM card contract	12	20,00	0%	240,00
ZM8C	8	320,00	0%	2.560,00
ZM8C-P	2	560,00	0%	1.120,00
Devices accessories	10	37,35	0%	373,50
Cable and tools devices	1	130,00	0%	130,00
Current transformer 80A	0	36,00	25%	0,00
Current transformer 150A	0	51,00	7%	0,00
Current transformer 300A	0	87,00	15%	0,00
Current transformer 500A	0	105,00	10%	0,00
<b>TOTAL</b>				<b>6.113,50 €</b>
<b>SET-UP AND CONFIGURATION</b>				
Setup databases & server	6	300,00	20%	1.440,00
Configuration del hardware	6	300,00	20%	1.440,00
Man-day partner support	2	1.050,00	0%	2.100,00
<b>TOTAL</b>				<b>4.980,00 €</b>
<b>Packing &amp; Shipping</b>				<b>200,00</b>
<b>TOTAL</b>				<b>11.293,50 €</b>

Table 18. Offer comparison 3

HARDWARE	DEZEM 1 <sup>1</sup>				DEZEM 2 <sup>2</sup>			
	Units	Price/Unit	Discount	Total Price	Units	Price/Unit	Discount	Total Price
iPCX with license for 10 metering tracks	1	950,00	0%	950,00	1	950,00	0%	950,00
Additional licenses	5	70,00	20%	280,00	5	70,00	20%	280,00
Din rail power supply 24 V	1	47,00	0%	47,00	1	47,00	0%	47,00
Modem	1	350,00	0%	350,00	1	350,00	0%	350,00
Accessories	1	43,00	0%	43,00	1	43,00	0%	43,00
SIM Card	1	20,00	0%	20,00	1	20,00	0%	20,00
Monthly SIM card contract	12	20,00	0%	240,00	12	20,00	0%	240,00
ZM8C	10	320,00	7%	2.976,00				
ZM8C-P	1	560,00	0%	560,00				
Devices accessories	11	37,35	0%	410,85				
Cable and tools devices	1	130,00		130,00				
Current transformer 150A	6	51,00	7%	284,58				
Current transformer 300A	45	87,00	15%	3.327,75				
Current transformer 500A	15	105,00	10%	1.417,50				
Rogowski coils	8	520,00	0%	4.160,00	20	520,00	10%	9.360,00

<sup>1</sup> DEZEM 1: 1 x iPCX, 1 x ZM8C-P, 10 x ZM8C, 8 x Rogowski

<sup>2</sup> DEZEM 2: 20 x Rogowski coils, 1 x iPCX

<b>TOTAL</b>	<b>15.196,68 €</b>	<b>11.290,00 €</b>
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<b>SET-UP AND CONFIGURATION</b>									
Setup databases & server	9	300,00	20%	2.160,00		6	300,00	20%	1.440,00
Configuration del hardware	9	300,00	20%	2.160,00		6	300,00	20%	1.440,00
Man-day partner support	2	1.050,00	0%	2.100,00		2	1.050,00	0%	2.100,00
Man-day Rogowski configuration	0,5	1.050,00	0%	525,00		1	1.050,00	0%	1.050,00

<b>TOTAL</b>	<b>6.945,00 €</b>	<b>6.030,00 €</b>
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<b>Packing &amp; Shipping</b>	300,00	300,00
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<b>TOTAL</b>	<b>22.141,68 €</b>	<b>17.620,00 €</b>
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Table 19. Final offer

	<b>DEZEM 2</b>			
<b>HARDWARE</b>	<b>Units</b>	<b>Price/Unit</b>	<b>Discount</b>	<b>Total price</b>
iPCX with license for 10 metering tracks	1,00	950,00	0%	950,00
Additional licenses	5,00	70,00	20%	280,00
Din rail power supply 24 V	1,00	47,00	0%	47,00
Modem	1,00	350,00	0%	350,00
Accessories	1,00	43,00	0%	43,00
SIM Card	1,00	20,00	0%	20,00
Monthly SIM card contract	12,00	20,00	0%	240,00
ZM8C				
ZM8C-P				
Devices accessories				
Cable and tools devices				
Current transformer 150A				
Current transformer 300A				
Current transformer 500A				
Rogowski coils	18,00	520,00	10%	8.424,00
<b>TOTAL</b>				<b>10.354,00 €</b>
<b>SET-UP AND CONFIGURATION</b>				
Setup databases & server	6,00	300,00	20%	1.440,00
Configuration del hardware	6,00	300,00	20%	1.440,00
Man-day partner support	1,50	1.050,00	0%	1.575,00
Man-day Rogowski configuration	1,00	1.050,00	0%	1.050,00
<b>TOTAL</b>				<b>5.505,00 €</b>
Packing & Shipping				300,00
<b>TOTAL</b>				<b>16.159,00 €</b>

Table 20. Extension offer

<b>HARDWARE</b>	<b>DEZEM</b>			
	<b>Units</b>	<b>Price/Unit</b>	<b>Discount</b>	<b>Total price</b>
iPCX with license for 10 metering tracks	0	950,00	0%	0,00
Additional licenses	0	70,00	20%	0,00
Din rail power supply 24 V	0	47,00	0%	0,00
Modem	0	350,00	0%	0,00
Accessories	0	43,00	0%	0,00
SIM Card	0	20,00	0%	0,00
Monthly SIM card contract	0	20,00	0%	0,00
ZM8C				
ZM8C-P				
Devices accessories				
Cable and tools devices				
Current transformer 150A				
Current transformer 300A				
Current transformer 500A				
Rogowski coils	2	520,00	10%	1.040,00
<b>TOTAL</b>				<b>1.040,00 €</b>
<b>SET-UP AND CONFIGURATION</b>				
Setup databases & server	0	300,00	20%	0,00
Configuration del hardware	0	300,00	20%	0,00
Man-day partner support	0	1.050,00	0%	0,00
Man-day Rogowski configuration	0	1.050,00	0%	0,00
<b>TOTAL</b>				<b>0,00 €</b>
Packing & Shipping				45,00
<b>TOTAL</b>				<b>1.085,00 €</b>

## APPENDIX B: Technical Data Sheets

- B.1. Technical data ZM8C
- B.2. Technical data iPCX
- B.3. Technical data current transformers



## ZM8C-P/ZM8C Módulos de medición

Abril 2012

# ZM8C-P y ZM8C

## Módulo para mediciones eléctricas y transmisión de los datos vía Modbus/RTU o CANopen

### Área de aplicación

Los módulos ZM8C-P y ZM8C permiten cada uno ocho canales de mediciones eléctricas, y la transmisión de los datos a un colector principal (por ejemplo, el deZem iPC41), entregando valores para cada canal de:

- Demanda eléctrica y consumo.
- Voltaje y corriente.
- Factor de Potencia.
- Admisión de datos basado en eventos, con un filtro configurable (en cada canal).
- Conexiones sencillas y prácticas con diversos transformadores de corriente.

### ZM8C-P y ZM8C

En su software y configuración, el ZM8C-P y el ZM8C son idénticos. La única diferencia entre ellos es que el ZM8C-P cuenta con un grupo de hardware extra para recibir la referencia de voltaje que se va a medir. Se pueden conectar hasta 4 ZM8C con un ZM8C-P y montarse uno al lado del otro de diferentes formas. Cada módulo tiene 2 conectores RJ45 y por cada uno se pueden conectar 4 transformadores de corriente ultra compactos (ver la hoja de datos correspondiente). Por lo tanto, se pueden conectar hasta 40 transformadores de corriente a esta configuración.

### Características

- Montaje en riel estándar (DIN)

- Adaptadores prácticos y sencillos para conectar los transformadores de corriente con cable-patch estándar (4 transformadores por cada cable patch).
- Intercambio, abastecimiento y transmisión de datos vía H-Bus o por cable plano con 10 pines de conexión.
- Actualización y configuración del software vía el bus de datos o a través de los push-buttons y su respectivo LED.
- Conector para la entrada de tensión.

### Datos técnicos

- Fuente de alimentación vía ZM8C-P o 5VCD
- Requerimientos de corriente: 45mA, máx. 80mA
- Dimensiones ZM8C: 90 x 55 x 61 mm, ZM8C-P: 90 x 105 x 61mm
- Temperatura de operación: -5 a 55 °C

### Interfaces físicas:

- 1x 16 pines H-Bus
- 1x 10 pines conector de cable plano
- 1x conexión para CANbus o RS485
- 1X conexión para 5VDC

### Sólo ZM8C-P:

- Entrada de tensión: L1 a N: 90 - 265VCA/120-385VCD, L2/L3 a N: 0 - 265VCA/0 - 385VCD
- Recepción de potencia L1 a N: 1.8VA, máx. 2.4VA, para conectar 4x ZM8C: máx. 8VA; L2/L3-N: máx. 0.2VA



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## iPCX: colector de datos industrial

PC industrial compacto, sin partes móviles, gran capacidad de almacenaje, con BACnet, Modbus, M-Bus, 1-Wire, CANopen, etc.

### Función

Conveniente conexión de datos para un amplio rango de sensores, medidores, buses de campo y fuentes de datos de todo tipo.

### Transmisión de datos

Transmisión segura, redundante y en tiempo real de los datos medidos (datos CSV via https o http) a servidores libremente configurables - locales o en la web - por ethernet (con autenticación Proxy, etc.) o inalámbricamente por stick UMTS o modem GPRS.

### Software de base

- Memoria cíclica de alto desempeño para almacenamiento local de un gran volumen de datos (> 3 millones de valores medidos).
- Resolución temporal/tasa de datos de hasta 1 s; sincronización temporal por NTP.
- Servidor web integrado; uso intuitivo, interfaz web protegida por contraseña (HTML5; sin plugins ni Java).
- Actualizaciones remotas, configuración remota.

### Módulos de software opcionales (en cualquier combinación)

- **Cliente BACnet** (BACnet-2010, Rev. 12) con diversas opciones de escáner y configuración para BACnet/IP para detección automática y lectura de todos los dispositivos BACnet en la red, incluyendo sus objetos y propiedades.

- **Maestro Modbus** para redes Modbus/RTU y dispositivos Modbus TCP; función de plantilla para rápida creación y configuración de dispositivos.
- **Bus 1-Wire** que integra todos los sensores del estándar 1-Wire (temperatura, humedad, señales analógicas, etc.); escáner para detectar automáticamente dispositivos y sensores.
- **Cliente BACnet** (BACnet-2010, Rev. 12) con diversas opciones de escáner y configuración para BACnet/IP incl. detección automática y lectura de todos los dispositivos BACnet en la red, incluyendo sus objetos y propiedades.
- **M-Bus** con convertidor de nivel integrado (máx. 60 cargas estándar); compatible con cualquier medidor, proveedor, modelo, etc.; escáner para detectar automáticamente los medidores M-Bus en todos los segmentos conectados directamente o via ethernet.
- **wM-Bus (M-Bus inalámbrico)** de acuerdo al Open Metering Standard (OMS), soporta los modos S y T; escáner para detección automática de medidores wM-Bus.
- **Maestro CANopen** para redes CANopen de hasta 500 pistas de medición.
- **Profibus, KNX, EnOcean** - y muchos más a través de gateways.
- Diversas **interfaces especiales** versátiles para conectar con sistemas de gestión de edificios, PLC's, estaciones meteorológicas, etc.



### Especificaciones técnicas

Almacenamiento:  
tarjeta microSD 2 - 8 GB opcional  
Fuente de alimentación: 24 VDC  
Consumo de energía sin periféricos:  
94 mA / 110 mA / 1 A (mín / típ / máx)  
Fusible interno: 1.1 A  
Dimensiones: (AxAxL) 62.9x107.6x89.7 mm  
Ensamblaje: rail DIN  
Peso: 190 g

**Interfaces:**  
4 inputs universales (0-10 VDC o digitales)  
2 inputs de corriente 4-20 mA  
4 interfaces seriales:  
1 x RS232 sobre RJ45  
1 x RS485  
1 x CAN-Bus  
1 x M-Bus  
2 x USB-Device / 1 x USB-Host  
1 x RJ45 Ethernet 10/100 Mbit/s  
2 outputs analógicos 0-20 mA  
2 outputs digitales (max. 200 mA)  
2 x Power Out 5 VDC en total máx. 500 mA  
6 x Power Out 24 VDC en total máx. 200 mA

#### Condiciones de operación aceptables:

Temperatura: 0 - 85 °C  
Humedad: 30 - 60 %  
Clase de protección: IP-20

#### Condiciones de transporte aceptables:

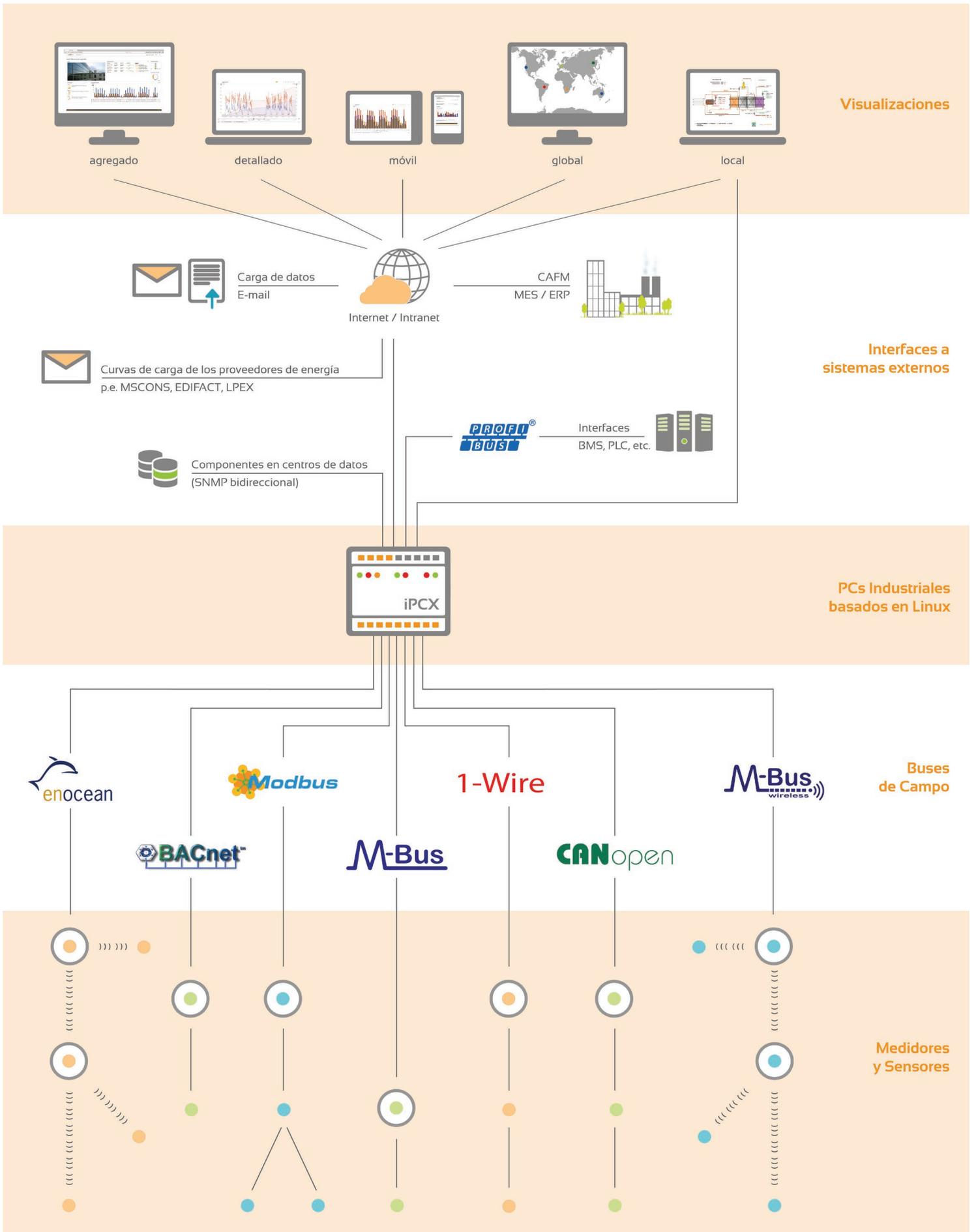
Temperatura: -40 - 85 °C  
Humedad: 20 - 70 %

sujeto a modificaciones técnicas  
Actualizado: Febrero 2017, JA

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Visualizaciones

agregado

detallado

móvil

global

local



Carga de datos  
E-mail



Internet / Intranet

CAFM  
MES / ERP



Interfaces a  
sistemas externos



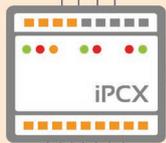
Curvas de carga de los proveedores de energía  
p.e. MSCONS, EDIFACT, LPEX



Componentes en centros de datos  
(SNMP bidireccional)



Interfaces  
BMS, PLC, etc.



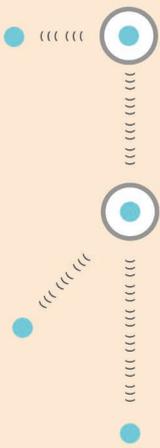
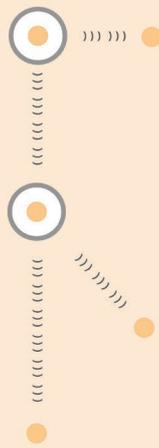
PCs Industriales  
basados en Linux



1-Wire



Buses  
de Campo



Medidores  
y Sensores



## Transformador de corriente

Ultra compacto, con alta relación de transformación  
Salida de hasta 250 mA (CA)

### Transformador de corriente

Sujeto a posibles cambios  
Revisión: Febrero 2017

#### Descripción

Estos transformadores de corriente son ideales para medir corriente eléctrica hasta 500A. Su dimensión, extremadamente compacta, hace posible su uso en donde otros convertidores no tienen lugar. Por ejemplo, se pueden utilizar con las conexiones sencillas y prácticas que ofrece nuestro equipo ZM8C, con cualquier combinación (ver la hoja de datos respectiva).

#### Aplicación

Medición de los parámetros eléctricos más importantes, ya sea en los tableros principales o secundarios de distribución, así como directamente en las cargas.

#### Características

- Alta relación de transformación, siendo posible su conexión a largas distancias.
- Fuente de alimentación no necesaria.
- Fácil de montar y conectar, con mínimo esfuerzo de cableado en la conexión, utilizando cable-patch estándar.
- Amplia gama de modelos para diferentes valores de corrientes.
- Temperatura de operación de -20 a 50 °C.
- Desde 150A: Salida con protección de diodos.
- Seguro contra incendio UL-94VO.
- desviación estándar < 1% para corrientes > 3% del valor nominal, utilizando deZem ZM8C.



#### Especificaciones Técnicas

Tipo	Corriente [A]	Diámetro ventana [mm]	Sección [mm <sup>2</sup> ]	Ancho [mm]	Alto [mm]	Prof. [mm]	Relac. de transform.	Max. corriente [A] (Is)	Diodo protecc.
W15 (B)	15	6,0	6	18,0	25,0	18,0	816	50	-
W80 (C)	80	9,5	50	26,5	40,0	26,5	3015	100	-
W150 (D)	150	16,0	150	31,0	44,5	29,0	3015	300	Si
W300 (E)	300	24,0	300	45,0	64,0	34,0	2000	1200	Si
W500 (F)	500	36,0	500	57,0	80,0	38,0	2000	2000	Si

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APPENDIX C: deZem Software Manual

# **deZem – Software corporativo para el control de energía**

## **Manual de Uso**

Junio 2019

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## 1. Introducción a deZem

Desde 2003, deZem ha estado desarrollando y distribuyendo software basado en la web para la gestión de recursos y energía de empresas, así como de autoridades públicas. Las competencias básicas de deZem consisten en la adquisición, visualización y análisis de los datos relevantes, así como en el soporte de los procesos necesarios de las diferentes partes interesadas.

El software deZem de control de energía es la central desde la cual se pueden gestionar y configurar sistemas de control de energía. Con un clic se puede ver cuanta energía es consumida en cada lugar, y como se relacionan ese consumo con la producción y parámetros medioambientales.

Dicho software puede ser utilizado no sólo para controlar la energía, sino también ver las contribuciones al control de calidad, el aumento de la productividad industrial, el mantenimiento, la administración de propiedades, la administración de instalaciones, la contabilidad, el monitoreo ambiental, la comunicación interna y externa, y muchas más.

Todas las mediciones convergen en potentes servidores, donde son verificadas, procesadas, y almacenadas en bases de datos. Desde el ordenador o teléfono móvil, se puede acceder a dicho servidor, para así poder representar y analizar datos actuales e históricos. Se pueden configurar alarmas y reportes, que serán enviados automáticamente.

Invisible para el usuario, deZem presta especial atención a la seguridad de la información y las recomendaciones de la Oficina Federal Alemana de Seguridad de la Información (BSI). El sistema deZem se examina regularmente para detectar posibles puntos débiles y los procesos de desarrollo están diseñados para prevenir tales deficiencias. Los administradores y desarrolladores de deZem otorgan la máxima prioridad a la seguridad y estabilidad del sistema. Las pruebas de penetración regulares realizadas por empresas especializadas forman parte del control de calidad y seguridad.

Finalmente, el software deZem está certificado con respecto a la compatibilidad con otros sistemas de gestión de energía ISO 50001. De hecho, las funcionalidades de los módulos de software disponibles van mucho más allá de los requisitos básicos de la norma ISO 50001.

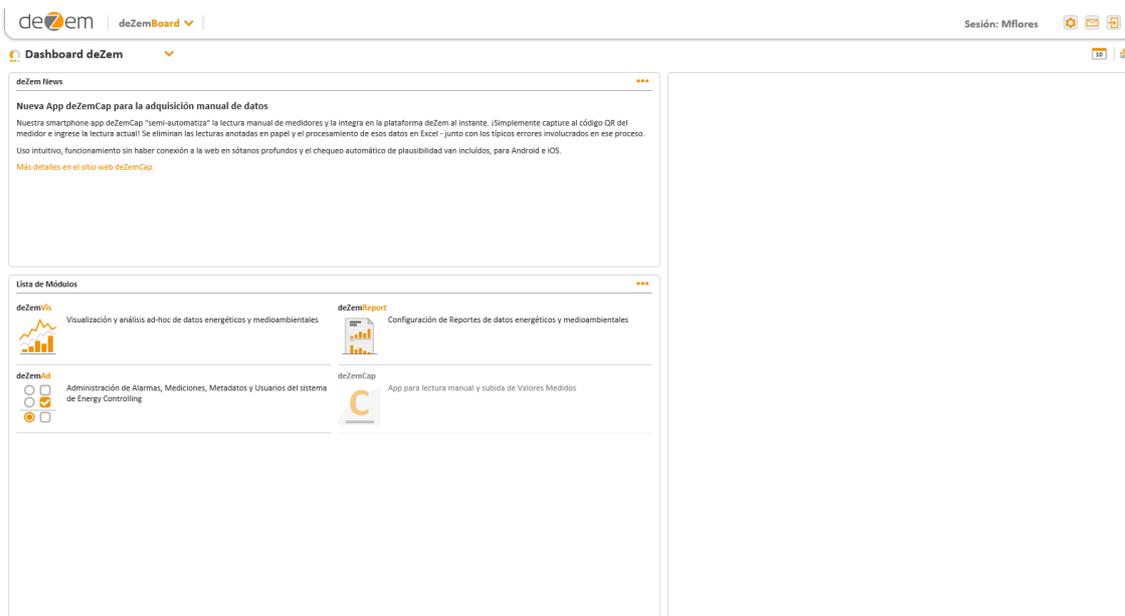
## 2. Beneficios del Software deZem

Se trata de un software profesional, preciso y de alto rendimiento. Desde Alemania lo están permanentemente actualizando. Además, tiene una alta resolución, se maneja de manera intuitiva y permite la visualización y análisis versátiles. No requiere de instalación y acepta un número de usuarios ilimitados. Es un software de alta seguridad, con centros certificados en Alemania y asistencia telefónica o por correo.

Además, tiene dashboards flexibles y adaptables, con decenas de widgets. Gráficos de proceso en tiempo real, fórmulas y medidores virtuales fáciles de configurar, importación y exportación de mediciones, app para la lectura manual de medidor con código QR.

### 3. Funcionalidades

Según se accede a la plataforma, la primera pantalla que aparece es el deZemBoard preestablecido por deZem. Este se muestra a continuación:



Aquí se pueden ver los cuatro módulos que permite el software:

- deZemVis: permite la visualización y el análisis de datos energéticos y medioambientales.
- deZemAd: administración de alarmas, mediciones, metadatos y usuarios del sistema de control de energía.
- deZemReport: permite sacar informes de datos energéticos y medioambientales.
- deZemCap: es una aplicación de lectura manual. Por el momento no está disponible esta funcionalidad.

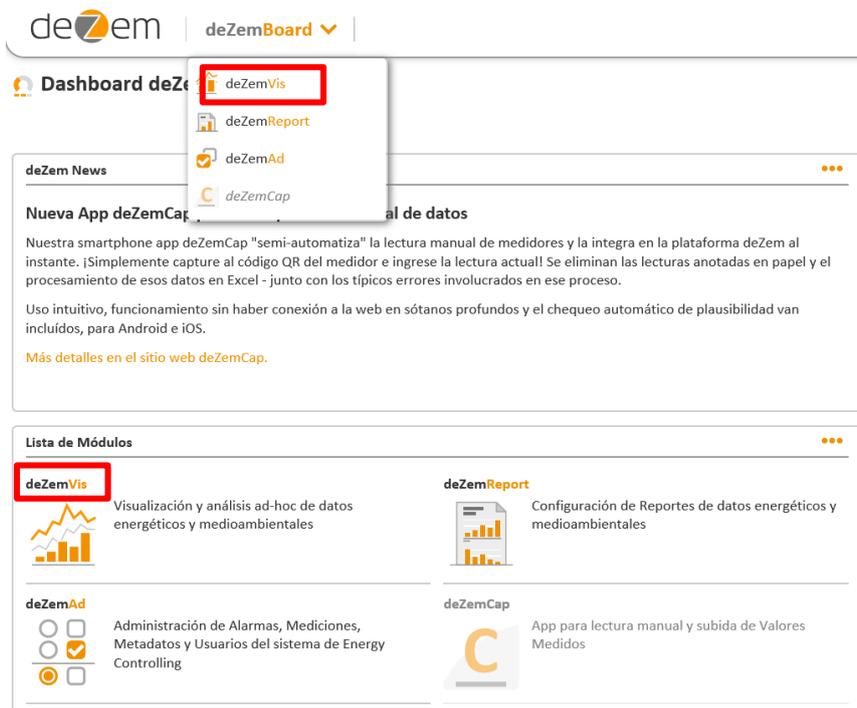
En los siguientes apartados se irá explicando en qué consiste cada uno, lo que permite hacer y cómo se hace.

#### 3.1. deZemVis

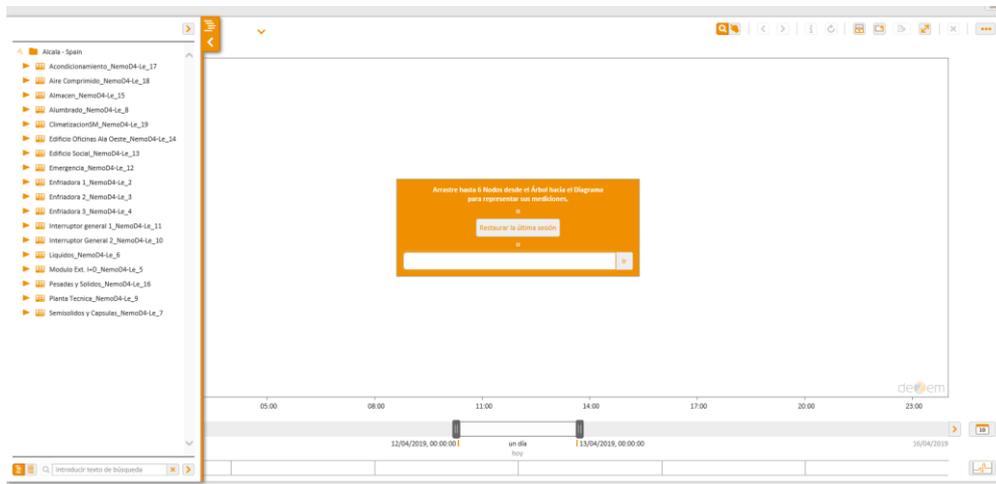
Este módulo de visualización interactiva permite tener vistas panorámicas en las que identificar ahorros potenciales, cuantificar cargas de base, entender cargas máximas, comparar periodos de tiempo, correlaciones, visualizar costes y ganancias en eficiencia.

## Definition and implementation of an energy management system

Para acceder a este módulo se puede acceder de dos formas. A través de la “Lista de Módulos” o bien, en el desplegable de la parte superior izquierda:



Una vez se accede a él a través de cualquiera de las dos opciones, aparece la siguiente pantalla:



En esta pantalla se puede observar a mano izquierda todos los nodos que se monitorizan. Actualmente, la planta sólo mide electricidad por lo que sólo aparecerá el primer icono de la siguiente lista. Sin embargo, la idea es tener todas las energías monitorizadas en un futuro. Por lo que, más adelante habrá nodos de otros parámetros.

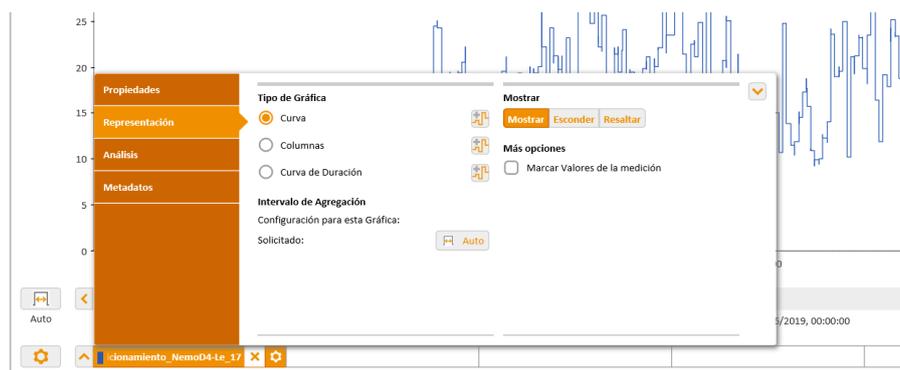
Unit Group	Symbol
Electricity	
Pressurized Air	
Gas	
IT	
Economy	
Heating and Cooling	
Miscellaneous	
Water	
Environmental Data	
Industrial Process	
Geographic Data	
Internal	
Oil	

Para crear los diagramas, se arrastran los nodos desde el Árbol de la izquierda hacia el diagrama. Así se representan las mediciones. Se pueden representar hasta 6 nodos a la vez.

Se pueden seleccionar amplios o breves intervalos de tiempo desplazando la barra de la parte inferior o en el icono , también se pueden marcar los fines de semana en el icono  de la parte inferior izquierda, especificar cada cuanto tiempo se quiere visualizar los datos en el icono  o cambiar el tipo de gráfico en .

Por otro lado, en la parte superior del diagrama, se puede introducir un título para el diagrama. También aparecen distintas opciones como son la de zoom , navegar , volver atrás/adelante , mostrar el sumario de los datos del periodo , actualizar , duplicar el diagrama , vaciarlo , exportarlo , verlo en pantalla completa  o guardarlo en .

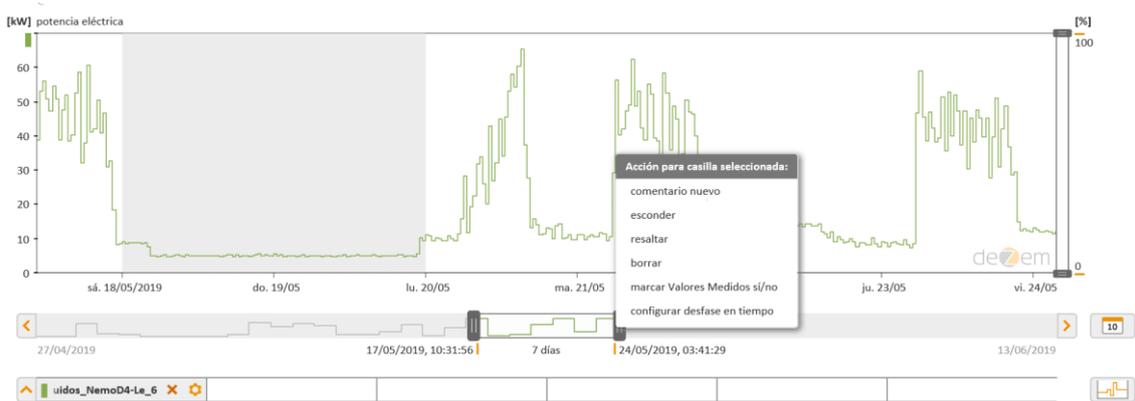
Para cada nodo seleccionado, en su correspondiente , se pueden ver sus propiedades, representación, análisis y si tiene o no metadatos.



Un ejemplo de gráfica es el siguiente:



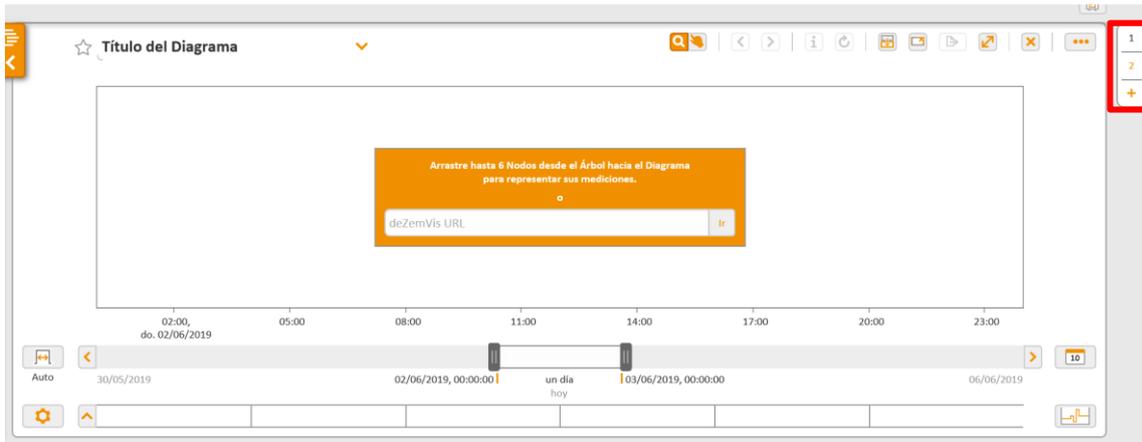
En el propio diagrama, se pueden resaltar puntos, añadir comentarios o esconder mediciones entre otras acciones. Para ello únicamente es necesario desplazarse encima de la curva y hacer clic con el botón izquierdo. Ante esto aparecerá la siguiente pantalla:



En cuanto a los tipos de diagrama, hay 7 opciones disponibles. Por defecto, viene el tipo de gráfico “Curva” pero se puede seleccionar cualquiera de los otros.



Por último, se pueden tener activos hasta 6 diagramas a la vez. A la derecha se pueden añadir.



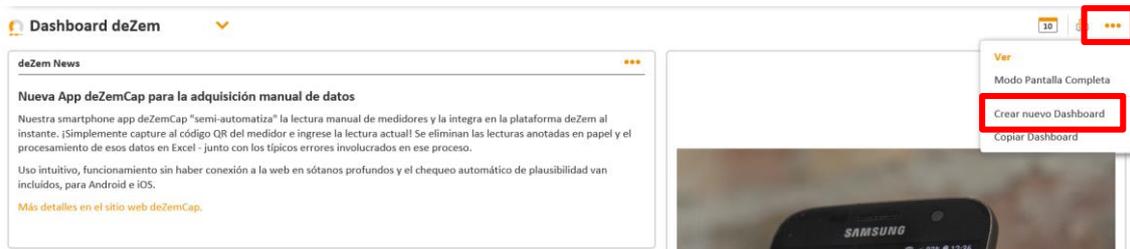
### 3.2. deZemBoard

deZemBoard es un sistema modular con un gran número de widgets interactivos, que se pueden configurar de forma rápida y sencilla. Esta función permite configurar dashboard<sup>3</sup> individuales, en los que incluir diagramas, mensajes, imágenes y otra serie de widgets o componentes para mostrar los principales datos energéticos del edificio. Permite obtener información específica, investigar anomalías, preparar reportes o administrar su sistema de control de energía. Se pueden crear uno o varios dashboards, haciéndolos más específicos de cada área interesada.

Pueden incluir mediciones relevantes, KPIs y el estado del proyecto bajo control específico para un grupo objetivo, actual e histórico, en cualquier lugar, a cualquier hora, con cualquier dispositivo.

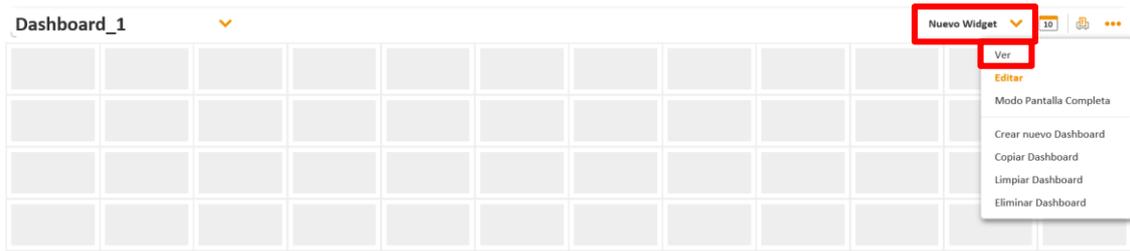
#### Crear un dashboard

Para crear un dashboard, se hace clic en el icono  de la derecha y en el desplegable se selecciona la opción “Crear nuevo Dashboard”.



A continuación, aparecerá la siguiente pantalla:

<sup>3</sup> Un dashboard es una representación gráfica de los principales indicadores (KPI) que intervienen en la consecución de los objetivos de negocio, y que está orientada a la toma de decisiones para optimizar la estrategia de la empresa.



Aquí, a través de las opciones del desplegable de “Nuevo Widget” se podrán ir introduciendo los elementos que se consideren interesantes. Una vez se hayan incluido todos los widgets, se hará clic en el icono  de la derecha y en “Ver” se saldrá de la edición del dashboard. Tal y como se puede ver en la imagen superior, se puede también copiar, limpiar (vaciar) o eliminar el dashboard.

### Diseñar o modificar un dashboard

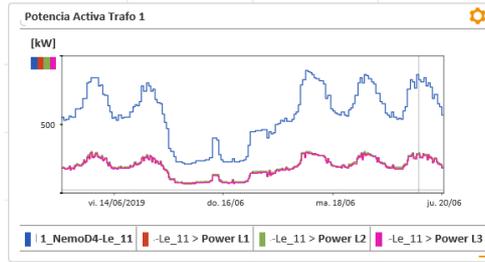
Para configurar el portal según los intereses de los usuarios, de nuevo en el icono , se selecciona la opción de “Editar”. En la lista de “Nuevo Widget” se puede elegir entre las siguientes opciones:



- **Lista de módulos:** se trata de un acceso a los cuatro módulos que ofrece el software y que se han explicado previamente.



- **Widget de diagrama:** permite introducir 7 tipos de diagramas con los datos disponibles. Para ello debe haberse creado y guardado algún diagrama en deZemVis previamente. Sino el software redireccionará al usuario a deZemVis para hacerlo.

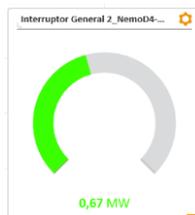


- **Widget de Texto:** se puede introducir texto a modo de aclaraciones, leyendas o cualquier otro tipo de mensaje. Para introducirlo o editarlo, se hace clic y “Editar”. Se abre entonces una pantalla en la que se programara el texto a introducir usando un lenguaje sencillo Markdown que se explica en esta pantalla mencionada. Para ver como se mostrará en el dashboard el texto, hay que darle a en la parte superior derecha. Para editar, . Para salir del modo edición, y “Ver”.

**Explicación Potencias**

Monitorizada, es el total de los medidores instalados en el resto de areas y equipos. Como se puede ver, no coincide y esto se debe a que no se han instalado analizadores en todas las áreas y equipos. Por ejemplo, quedan sin monitorizar el Edificio Servicios, Caldera, Ampliación Almacén, Baterías Condensadores 1 y 2, Nitrógeno, Grupo Bombas Frio, C.P.1 y la Sede Social. Se ha pedido oferta a deZem para incluir los consumos de las Bombas de Frio y la Sede Social.

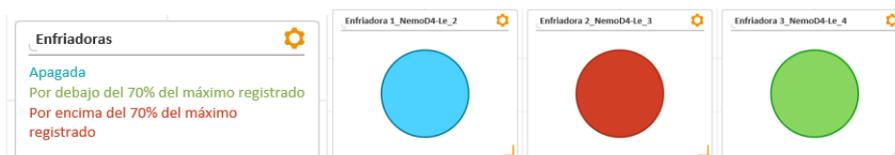
- **Widget de Imagen:** se pueden incluir imágenes en el dashboard como por ejemplo el logo de la empresa. Para ello, se hace clic y “Editar”. Aquí habrá que cargar la imagen deseada de acuerdo con los requisitos que el software establece. Para salir del modo edición, y “Ver”.
- **Widget de Tacómetro:** permite mostrar el nivel de utilidad de un nodo del árbol. Para ello habrá que establecer el mínimo y máximo que este puede alcanzar.



- **Widget de Cifra:** muestra el valor de los datos seleccionados.



- **Widget Punto:** parecido al Tacómetro, permite mostrar de manera visual el estado de la capacidad de los nodos seleccionados. Para ellos habrá que establecer unos límites máximos y mínimos para así diferenciar los distintos estados.



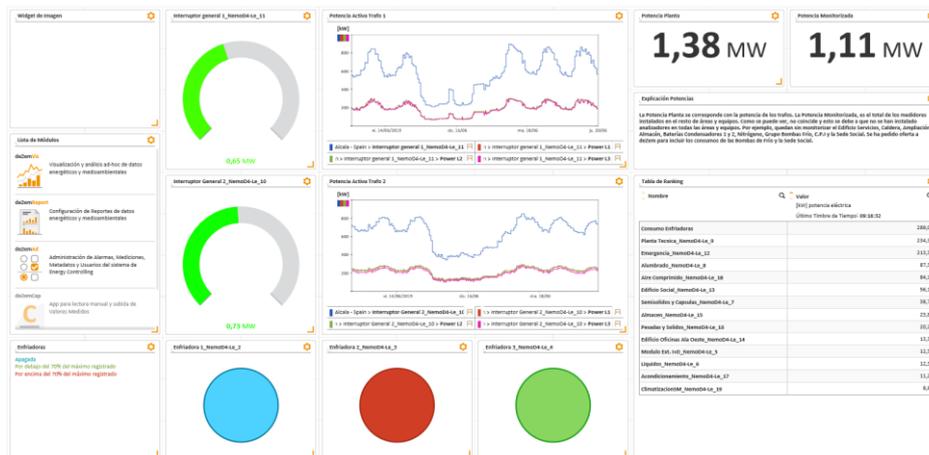
- **Widget Mapa de Sensores:** permite indicar en una imagen la localización de los sensores instalados.
- **Tabla de Ranking:** se pueden crear rankings con los nodos seleccionados, ordenarlos de mayor a menor o por nombre.

Nombre	Valor [kW] potencia eléctrica
Consumo Enfriadoras	290,04
Planta Tecnica_NemoD4-Le_9	234,29
Emergencia_NemoD4-Le_12	216,08
Alumbrado_NemoD4-Le_8	86,23
Aire Comprimido_NemoD4-Le_18	61,23
Edificio Social_NemoD4-Le_13	38,33
Semisolidos y Capsulas_NemoD4-Le_7	37,25
Almacen_NemoD4-Le_15	22,07
Pesadas y Solidos_NemoD4-Le_16	21,72
Modulo Ext. I+D_NemoD4-Le_5	12,38
Liquidos_NemoD4-Le_6	11,86
Edificio Oficinas Ala Oeste_NemoD4-Le_14	11,70
Acondicionamiento_NemoD4-Le_17	9,98

- **Widget de Link:** crea un acceso directo a otros dashboard ya creados.

Los widgets pueden ser ampliados o reducidos según interese haciendo clic en la esquina inferior derecha del elemento, en el icono . Para desplazar los elementos, es necesario hacer clic sobre estos con el botón derecho y con la rueda moverlo hasta el sitio deseado. Finalmente, para eliminarlos, en el icono de la esquina superior derecha de cada elemento, se tiene la opción de “Eliminar”.

Un dashboard podría visualizarse como el siguiente:



### 3.3. deZemReport

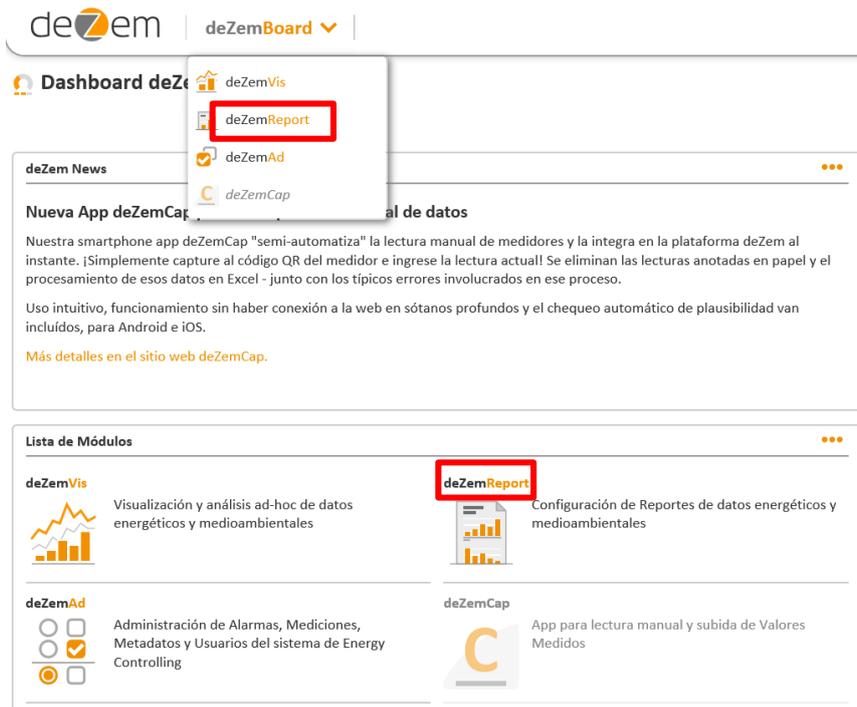
deZemReport es el módulo para configurar reportes energéticos y medioambientales, que serán enviados periódicamente por correo electrónico de forma automática. El objetivo es:

- No perder de vista los costes
- Permanecer informado sobre el desarrollo de valores característicos

- Comparar el consumo actual con los años previos
- Monitoreo sostenible de éxitos en el ahorro

La particularidad del deZemReport es su sencilla configuración, en la que el usuario será guiado paso por paso, tras la cual el reporte terminado podrá ser revisado. Los reportes serán enviados diaria, semanal, mensual o anualmente a grupos de usuarios configurados libremente.

Para acceder a este módulo se puede acceder de dos formas. A través de la “Lista de Módulos” o bien, en la parte superior izquierda:



Una vez se hace clic en deZemReport, aparece la siguiente pantalla:

**Vista general**

Esta es la lista de Reportes asociados a su cuenta. Cree uno nuevo, o seleccione un Reporte ya existente.

➕ AGREGAR REPORTE!

	Intervalo a reportar	Destinatario	Activo
Consumos SS 5	diario		↻ <input type="checkbox"/>
Consumos SS 4	diario		↻ <input type="checkbox"/>
Consumos SS 3	diario		↻ <input type="checkbox"/>

Desde aquí se pueden crear nuevos informes en “Agregar reporte” o consultar los que ya se han hecho.

Para cada nuevo informe, hay 4 pasos que seguir.

1. **Nombrar el reporte:** también se podrá añadir una breve descripción del contenido.
2. **Escoger el contenido:** se elegirá el nodo o nodos que se quieren en el informe y el intervalo de tiempo. También se puede seleccionar distintas unidades [u], agregar tiempos de comparación [E], añadir puntos adicionales +/~, seleccionar distinto tipo de diagrama [■] o eliminarlo [X].
3. **Seleccionar destinatario:** si se desea enviar el reporte de manera periódica a un destinatario o a un grupo, se especificará en este paso.
4. **Terminar:** finalmente se podrá indicar la frecuencia de envío de los reportes. También en este paso se podrán hacer las siguientes acciones:

En el caso de querer consultar, modificar o eliminar un reporte, únicamente hará falta acceder a él desde la pantalla inicial y esto conducirá al paso de Terminar, previamente explicado. Desde este, se puede volver a cualquier de los otros tres pasos.

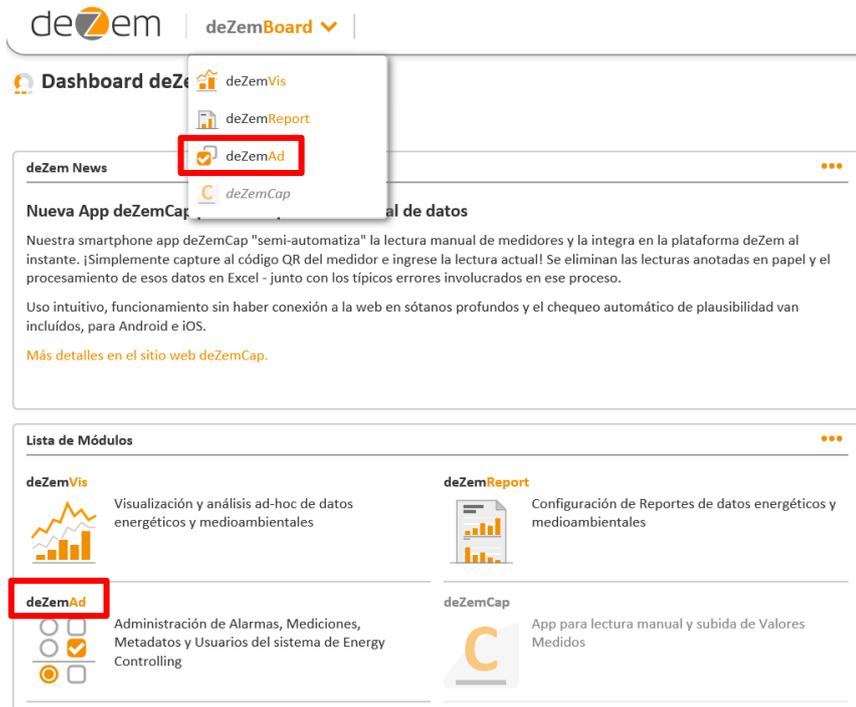
### 3.4. deZemAd

deZemAd es el módulo de Software con el que clientes configuran y desarrollan su sistema de control de energía completa o parcialmente.

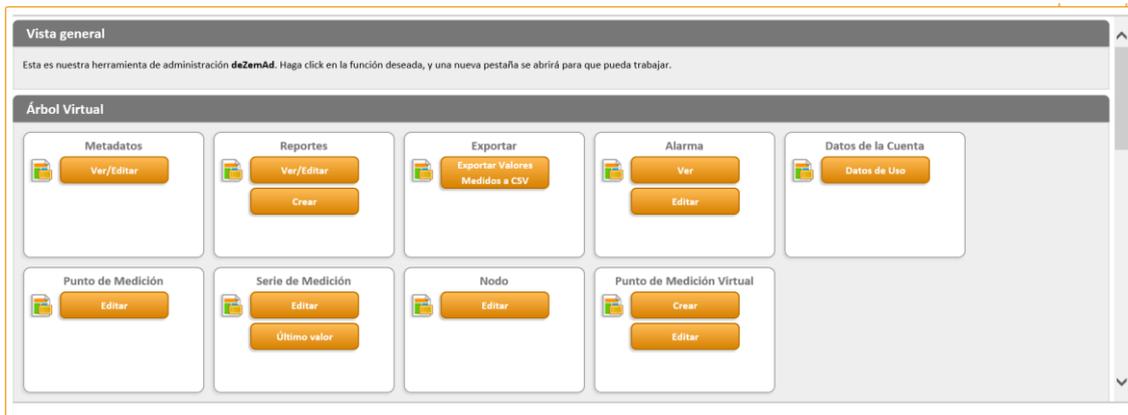
Con el concepto de la tenencia múltiple se pueden distribuir derechos para gestionar y utilizar el sistema de control de energía de una manera más o menos amplia, sobre cualquier número de personas, por ejemplo:

- Administradores de sistemas enteros y subsistemas
- Técnicos de mantenimiento de niveles de campo específicos
- Administrador para alarmas y reportes
- Responsable del mantenimiento de datos de usuarios y metadatos

Para acceder a este módulo se puede acceder de dos formas. A través de la “Lista de Módulos” o bien, en el despegable en la parte superior izquierda:



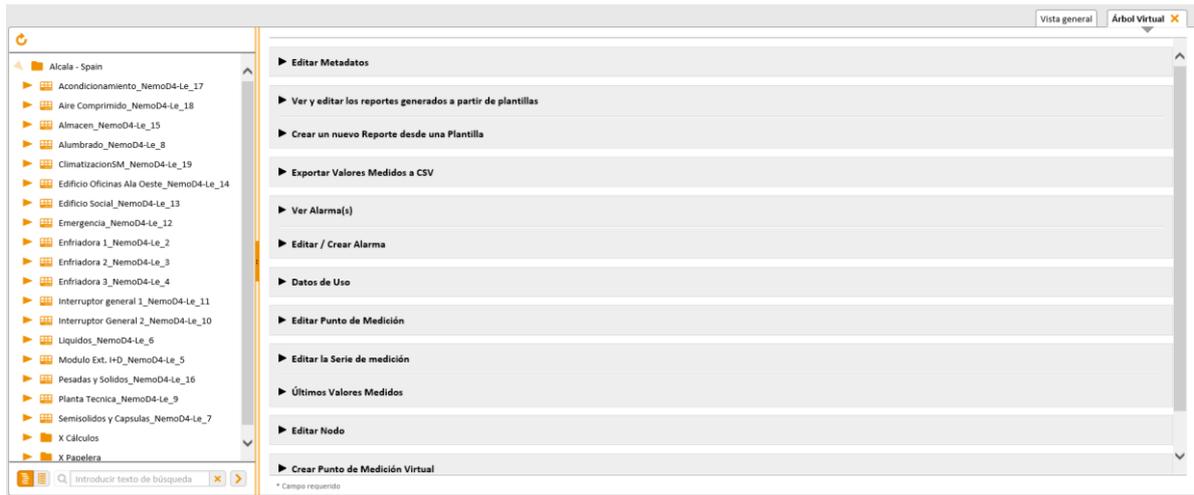
Una vez se ha accedido a este apartado, aparece la siguiente pantalla:



En ella se podrá acceder a:

### Árbol Virtual

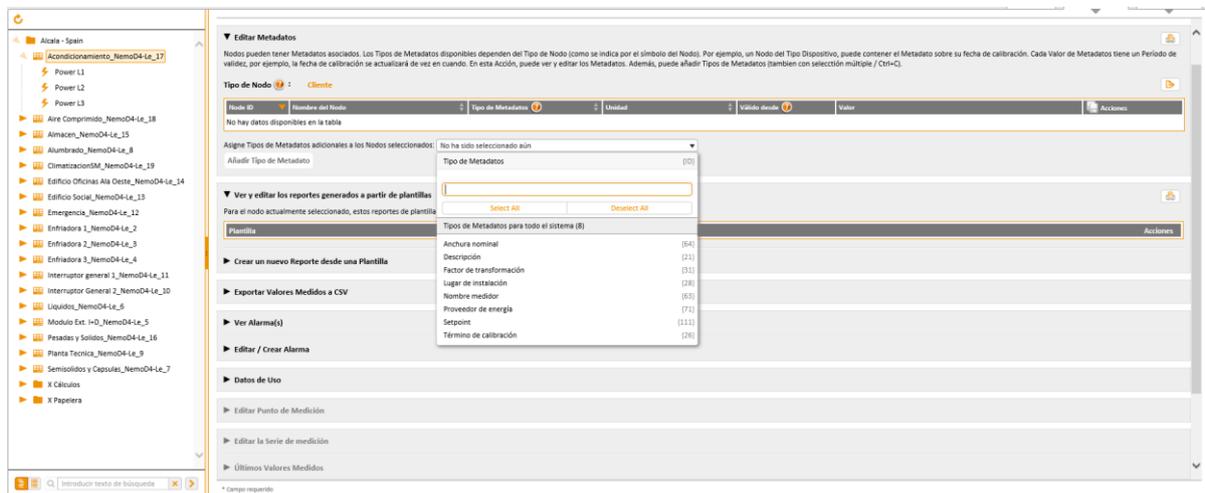
Aquí se puede acceder a la configuración de cada uno de los nodos de los que dispone el sistema.



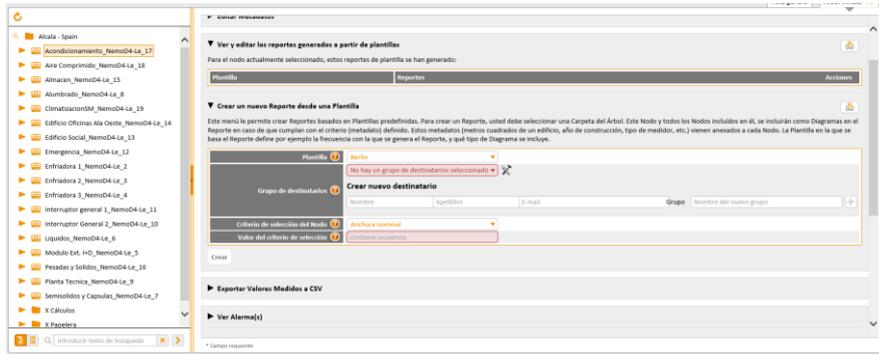
A continuación, se presentará brevemente lo que estos incluyen. Únicamente se hará de los que pueden resultar de interés.

### Editar Metadatos

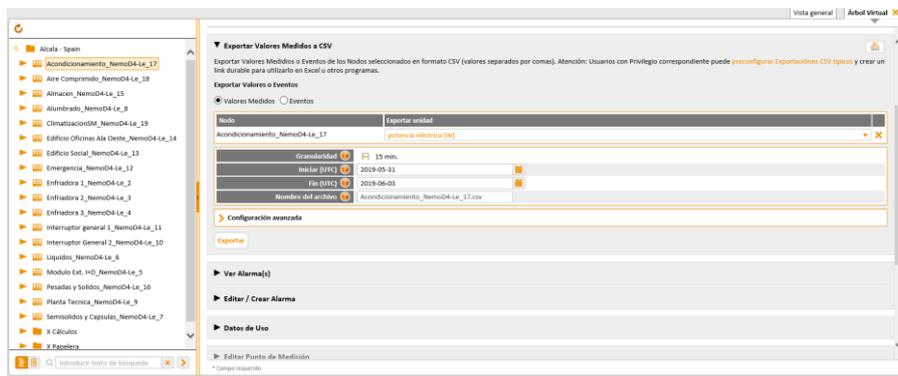
Los metadatos son datos que describen otros datos o "datos sobre datos". Los nodos pueden tener Metadatos asociados. Los tipos de Metadatos disponibles dependen del tipo de Nodo (como se indica por el símbolo del Nodo). Por ejemplo, un Nodo del tipo dispositivo, puede contener el Metadato sobre su fecha de calibración. Cada valor de Metadatos tiene un período de validez, por ejemplo, la fecha de calibración se actualizará de vez en cuando. En esta acción, puede ver y editar los Metadatos.



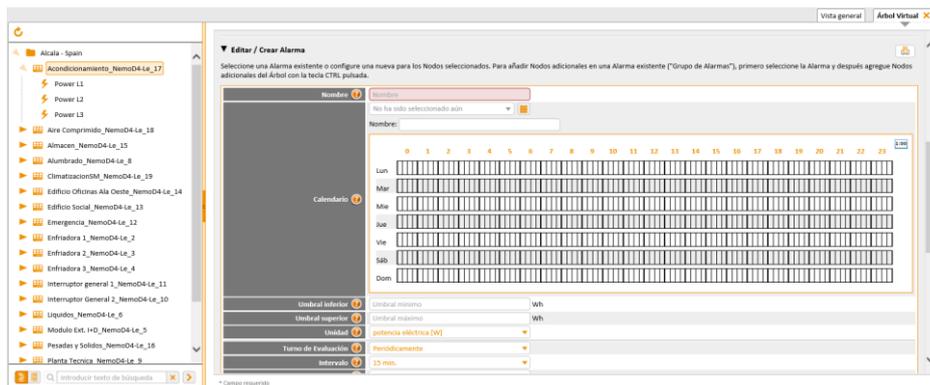
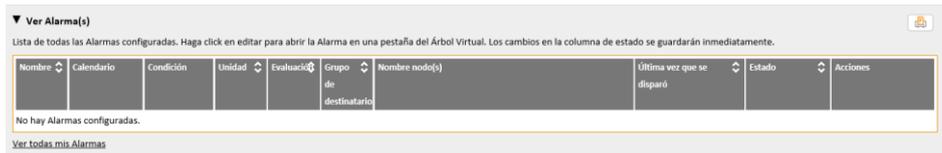
*Ver y editar los reportes generados a partir de plantillas/Crear un nuevo reporte desde una plantilla*



*Exportar Valores Medidos a CSV*



*Ver Alarma(s)/Editar o crear Alarma*



*Editar Serie de medición*

Este apartado permite modificar los nombres de los puntos de medida. Para ello, haciendo clic en cualquiera de los puntos, se abre el desplegable con las tres fases. Se selecciona cualquiera de ellas. A la derecha, desplegando la opción de “Editar la Serie de medición”, se puede

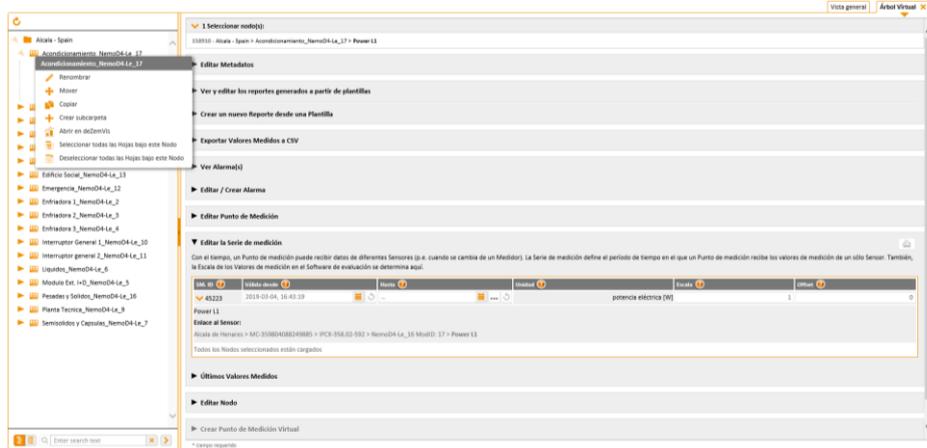
comprobar en el “Enlace al Sensor” el equipo (ModID-X) al que está asignado el punto de medición.

Ej: Alcalá de Henares > MC-359804088249885 > IPCX-358.02-592 > NemoD4-Le\_17 **ModID: 18**  
 >Power L1

En el nombre deberá aparecer este número también.



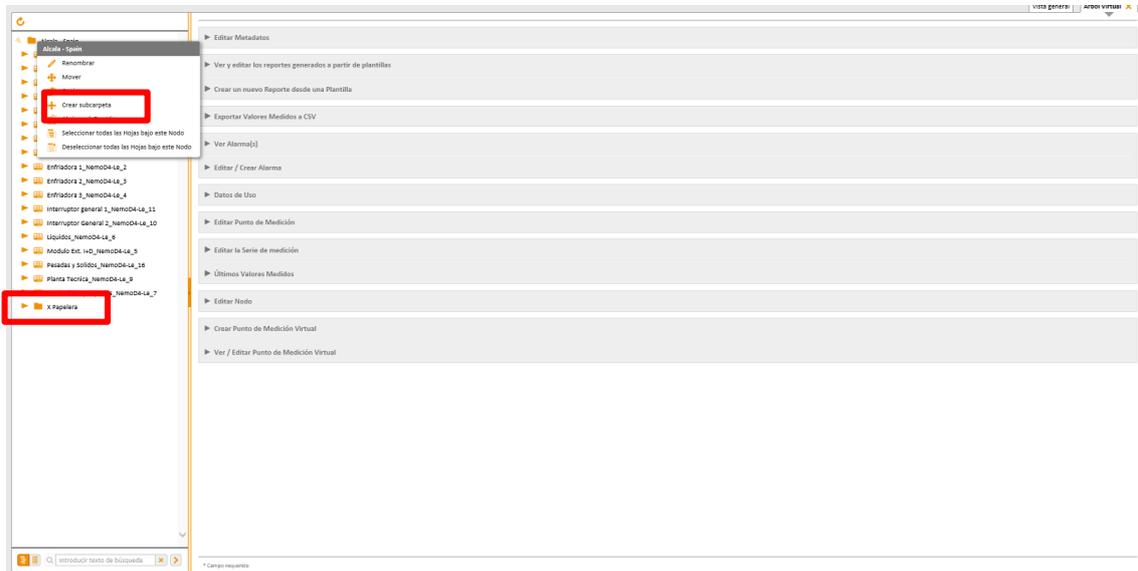
Si no fuera así, situándose encima del icono de uno de los puntos, aparecerá una rosca. Botón izquierdo y renombrar.



***Crear Punto de Medición Virtual/ Ver o Editar Punto de Medición Virtual***

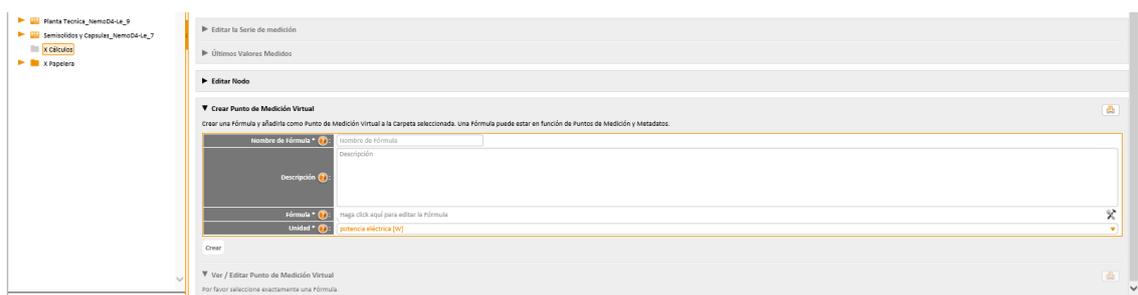
Lo primero, antes de crear cualquier punto, para tener el árbol más organizado, se han creado dos subcarpetas. Como los puntos de medición virtual no se pueden borrar, se crea una carpeta de “Papelerera” para colocar allí todos aquellos puntos que ya no se usen o sean erróneos. También se crea otra carpeta a la que se ha llamado “Cálculos” en la que meterán los puntos de interés y KPIs.

Para crear cualquier carpeta, en la pantalla del “Árbol Virtual”, se sitúa el ratón sobre la carpeta de “Alcala” y, cuando aparezca el icono , botón izquierdo y aparecerá el siguiente desplegable. Aquí se elige la opción de “Crear subcarpeta”, se nombra y guarda.



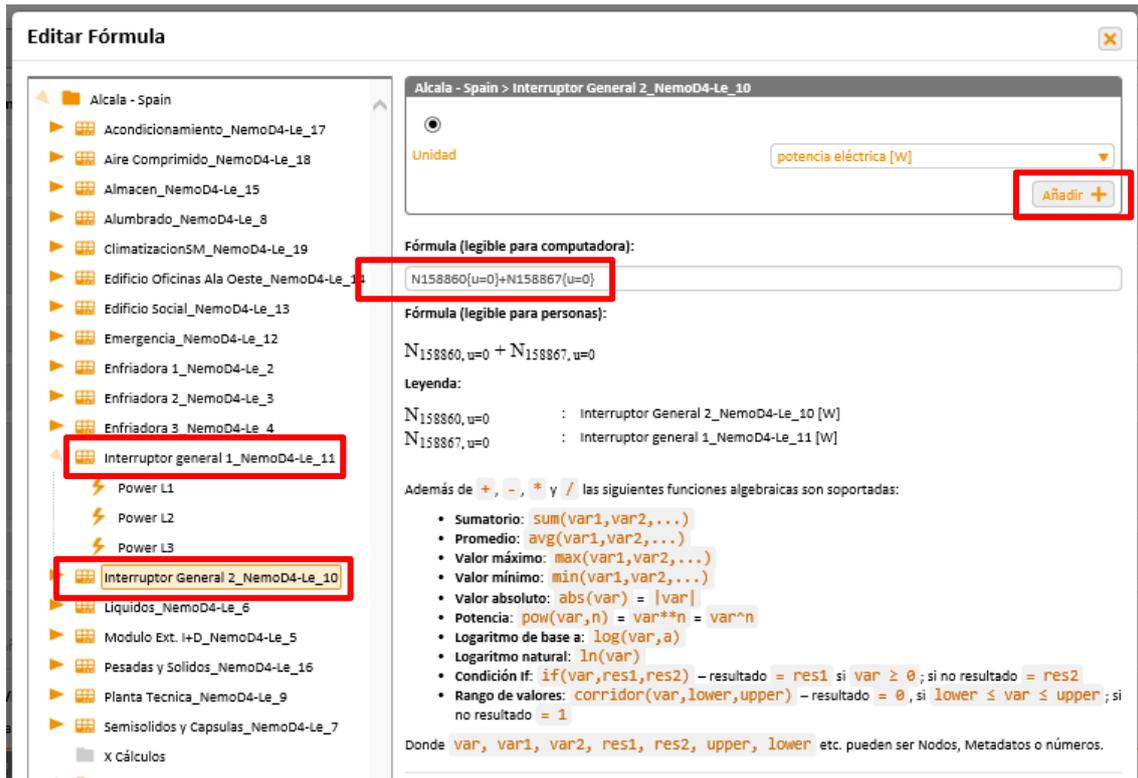
Una vez se tiene la carpeta, se puede crear o modificar un punto de medición virtual. Por ejemplo, se crea un punto para medir la potencia total de la planta. Esta es, la suma de los dos trafos y no de “Alcala” como se pensaba de primeras. Bajo el nombre de “Alcala”, están los consumos de todas las áreas monitorizadas y de los trafos.

Haciendo clic sobre la carpeta de “Cálculos”, se despliega la opción de “Crear Punto de Medición Virtual” para crearlo. Si fuera modificarlo, habría que situarse sobre el punto ya creado y se desplegaría la opción de “Ver/Editar Punto de Medición Virtual” y se hace clic en el icono  de la derecha.



Aquí se introduce el Nombre de la Fórmula, la Fórmula y la Unidad. Para este caso:

- **Nombre de la Fórmula:** Potencia Planta
- **Fórmula:** se selecciona los nudos de interés. Se pueden sumar, multiplicar, dividir... En este caso esta será: Interrupor General 1 + Interrupor General 2. En el software, para introducir la fórmula, se selecciona el nodo y en la parte superior derecha se da a “Añadir”:



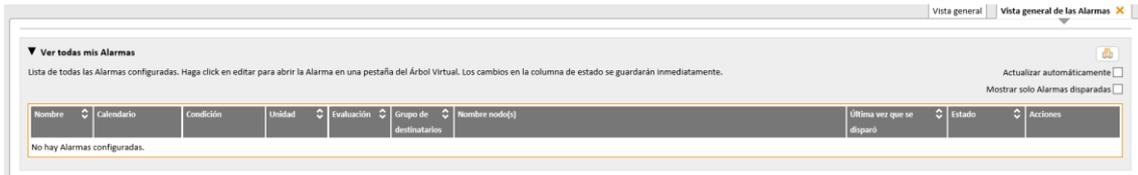
Una vez se tiene la fórmula deseada, se le da a “Ok”.

- **Unidad:** potencia eléctrica (W).

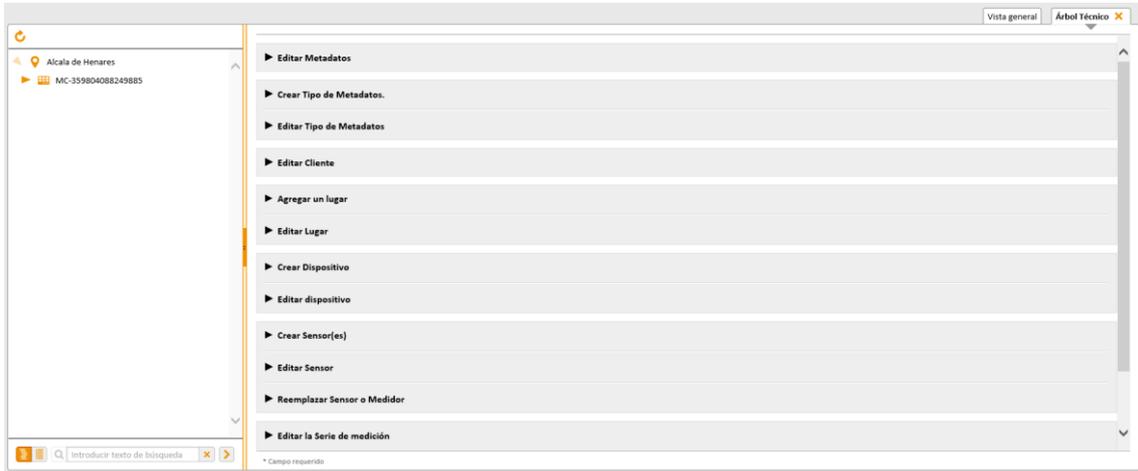
Para mover un punto virtual a otra carpeta, simplemente sitúa el ratón sobre el icono ⚡ y una vez que aparezca ⚙️, botón izquierdo, y se selecciona la opción de “Mover”.

### Vista General de Alarmas

Aquí se podrán ver un listado de las alarmas que hayan sido configuradas en el Árbol Virtual. En el caso de querer editar alguna, el software redireccionará a este Árbol Virtual



### Árbol Técnico



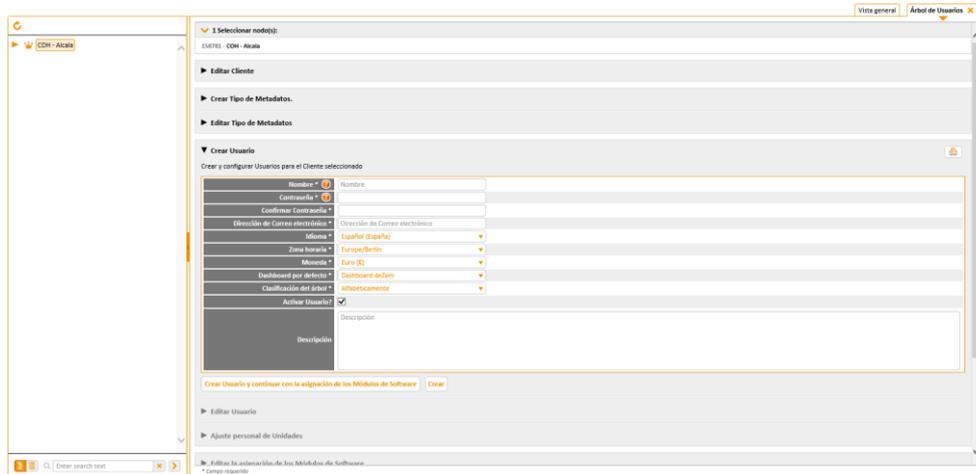
### Árbol de Usuarios

El Árbol de Usuarios presenta la siguiente interface en el que se puede observar las acciones disponibles a la derecha. A la izquierda, los usuarios con acceso a los datos del sistema.



### ¿Cómo crear/editar usuarios?

Se hace clic encima del “Árbol de Usuarios” y saltará la siguiente pantalla:



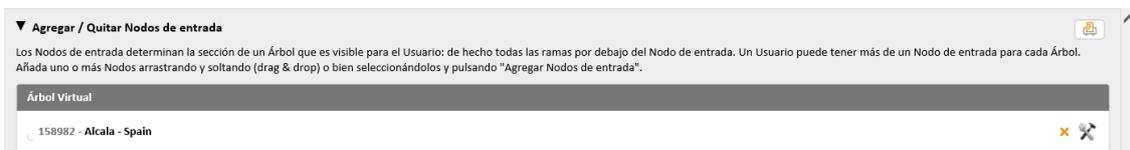
- Crear Usuario: especificar Nombre, Contraseña y Correo electrónico. Crear Usuario y continuar con la asignación de los Módulos de Software.
- Editar la asignación de los Módulos de Software: seleccionar todos. ¿Importación? Guardar la asignación y continuar con la configuración de los Privilegios.

Nota: hay que tener cuidado de que la persona responsable de todo, no deselectione los módulos de software (todos seleccionados) porque no podrá volver a reasignárselo a sí mismo.

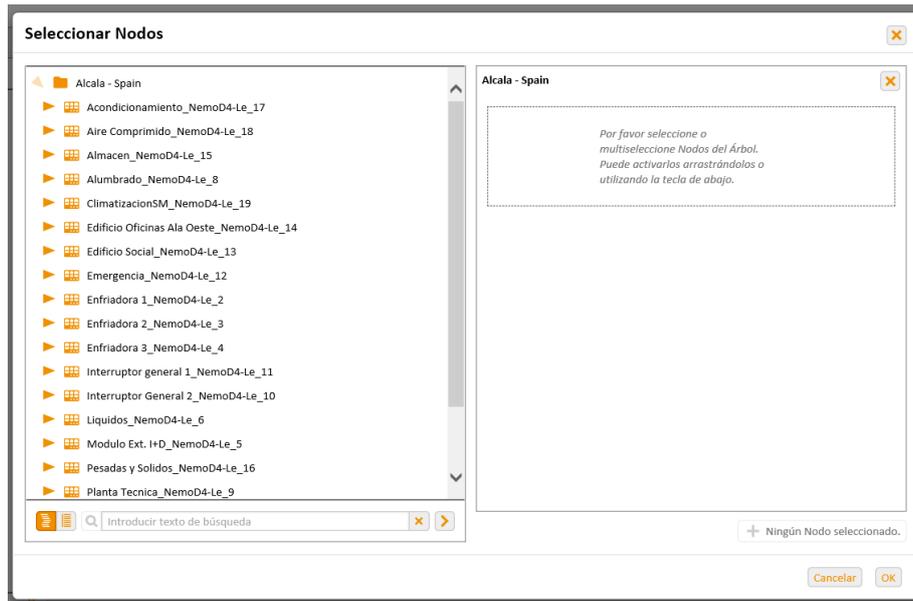
- Editar Privilegios: seleccionar todos los módulos de deZemVis y deZemBoard. De deZemAd, deselectione los privilegios generales (menos la exportación), gestión de mediciones y gestión de usuarios. Guardar los privilegios y continuar con la asignación de nodos de entrada.

Nota: únicamente debería tener todos los privilegios una persona.

- Agregar/Quitar Nodos de entrada: en este desplegable se puede dar acceso a los usuarios a los datos en el **Árbol Virtual**. Haciendo clic en :



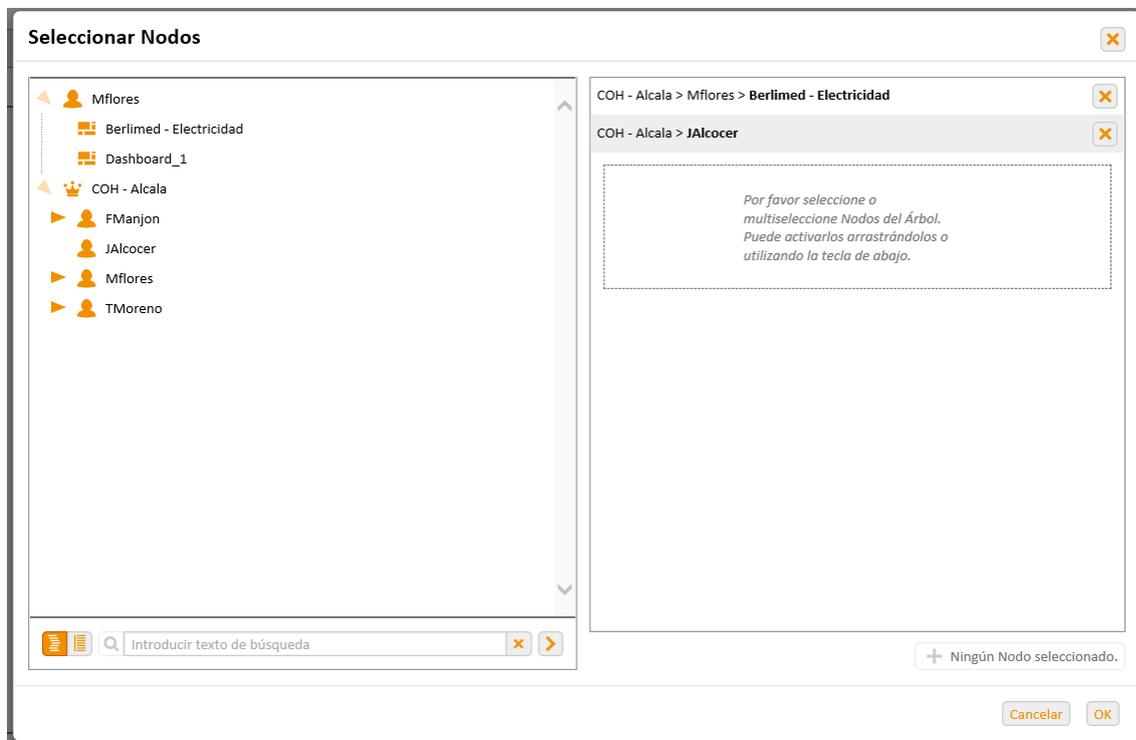
Aparecerá la siguiente pantalla en la que se arrastrará a la parte de la derecha los datos que se requieran. Idealmente será la carpeta que englobe todas las medidas:



Si se quiere eliminar el acceso, se hará clic en el icono ✕.

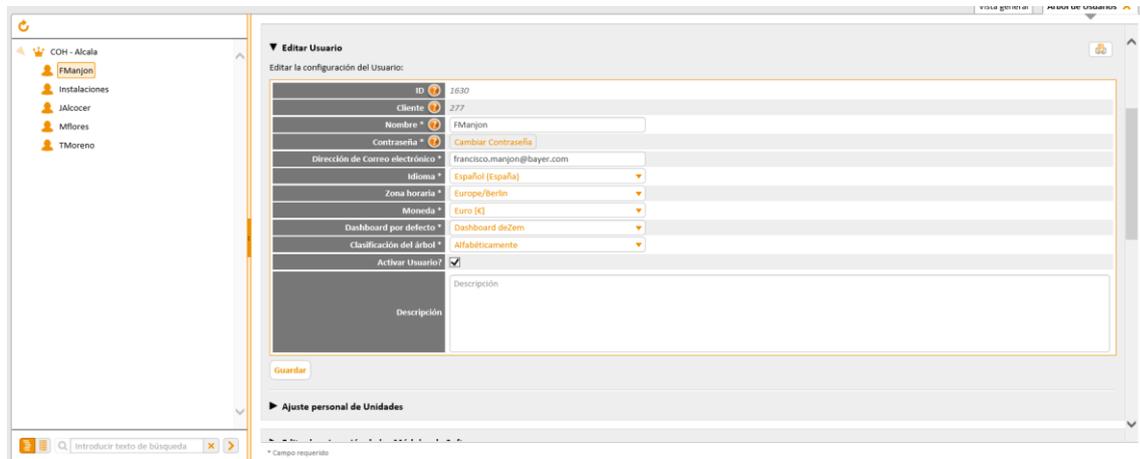
Para dar acceso al dashboard creado por uno de los usuarios:

Se seleccionará el usuario al que se quiere dar acceso. En Agregar/quitar Nodos de entrada, en el Árbol de Dashboards, se hace clic en el icono ✕ y se abrirá la siguiente pantalla:



Aquí se seleccionará el Dashboard y se arrastrará a la parte derecha. Si se quiere eliminar el acceso, se hará clic en el icono ✕.

Una vez creados, se pueden modificar en Editar Usuario. Por ejemplo, se podrá cambiar el nombre, correo, idioma, o el dashboard por defecto.



### 3.5. deZemCap

La Smartphone app deZemCap "semi-automatiza" la lectura manual de medidores y la integra en la plataforma deZem al instante.

Los pasos a dar son:

- Seleccionar un medidor de la lista o capturar automáticamente al código QR del medidor,
- Modificar los dígitos que han cambiado desde la última lectura,
- Guardar.

También incluye una verificación de plausibilidad inmediata para evitar la introducción accidental de errores. El uso es intuitivo, fácil y seguro.

deZemCap también funciona sin haber conexión a la web: las nuevas lecturas son transferidas a la plataforma al haber conexión nuevamente.

Así se eliminan:

- el gasto exagerado de tiempo resultante de lecturas anotadas en papel,
- los errores involucrados en ese proceso,
- los típicos errores humanos que ocurren en el procesamiento de esos datos en Excel.

Por el momento, no está disponible.

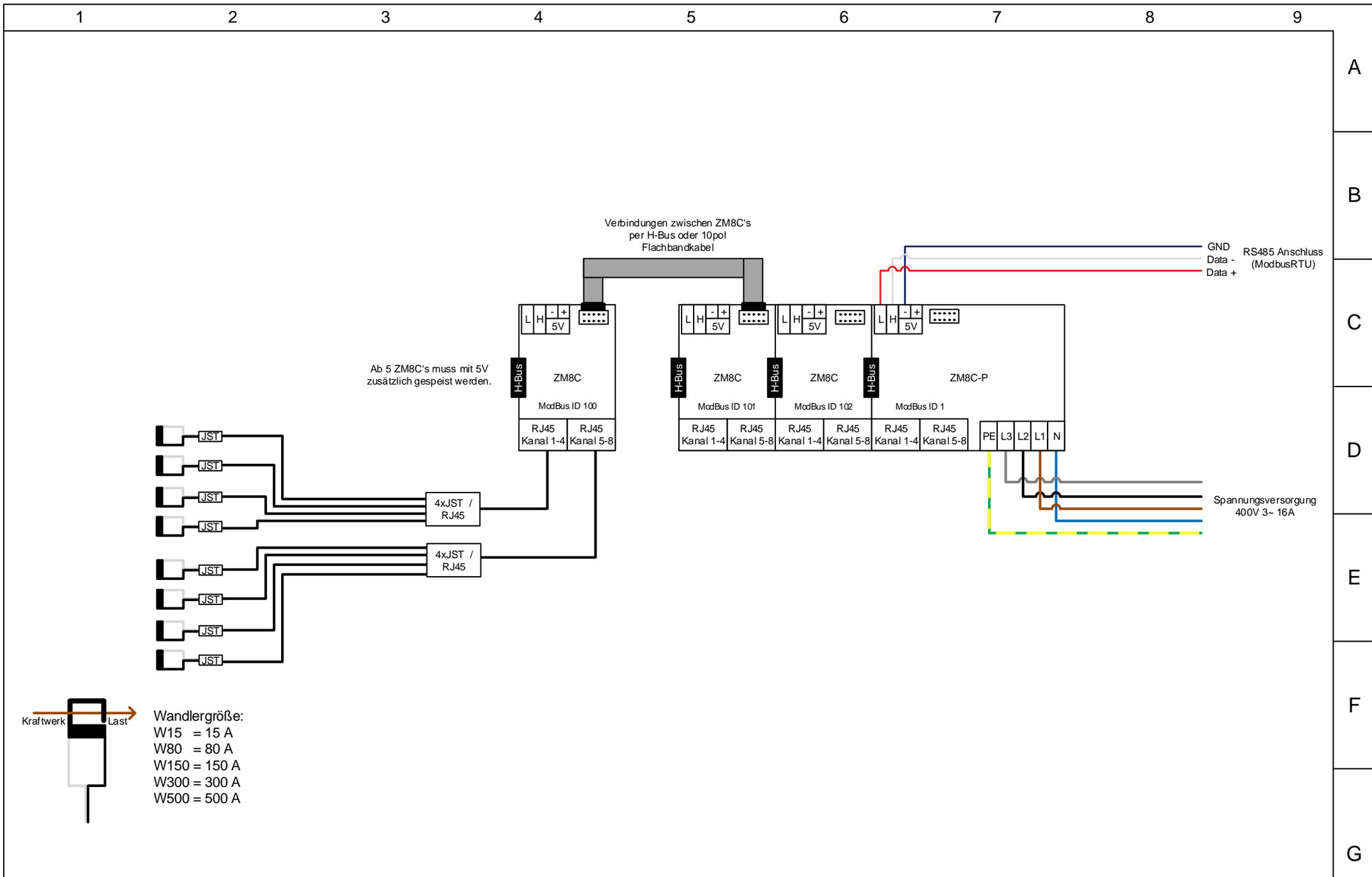


## 9. TECHNICAL SHEETS AND PLANS

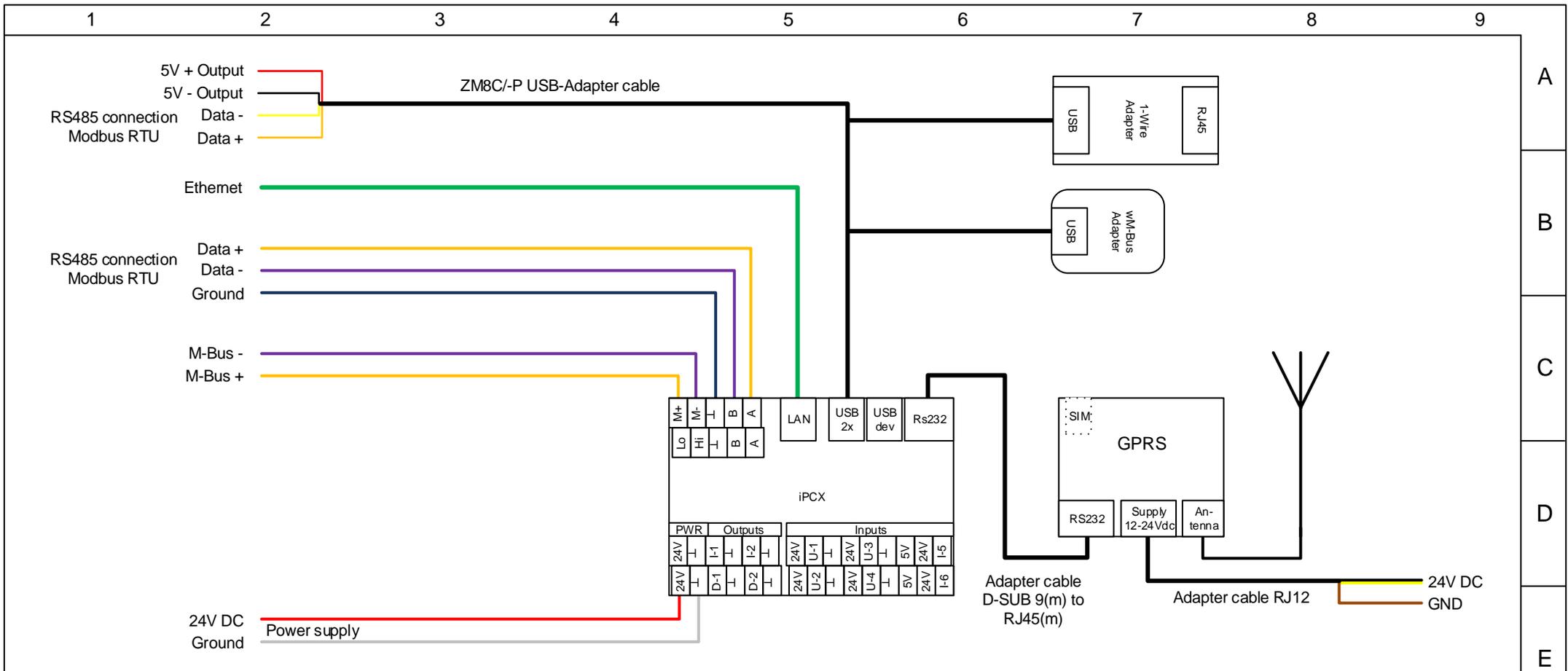
Finally, the connection and single-line diagrams consulted are collected. To try to be as clear as possible, they have been numbered as follows:

- Plan 1. ZM8C connection diagram
- Plan 2. iPCX connection diagram
- Plan 3. Rogowski connection diagram
- Plan 4. iPCX + Modem connection diagram
- Plan 5: General plan of the site
- Plan 6. Low Voltage General Switchboard diagram
- Plan 7. Planta Tecnica diagram
- Plan 8. Modulo Ext. I+D diagram
- Plan 9. Liquidos diagram
- Plan 10. Semisolidos y Capsulas diagram
- Plan 11. Alumbrado diagram
- Plan 12. Edificio Social diagram
- Plan 13. Edificio Oficinas Ala Oeste diagram
- Plan 14. Almacen diagram
- Plan 15. Pesadas y Solidos diagram
- Plan 16. Acondicionamiento diagram
- Plan 17. Aire Comprimido diagram
- Plan 18. Emergencia diagram

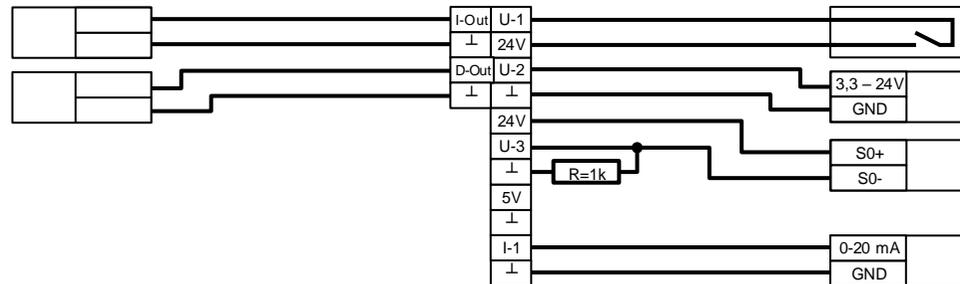




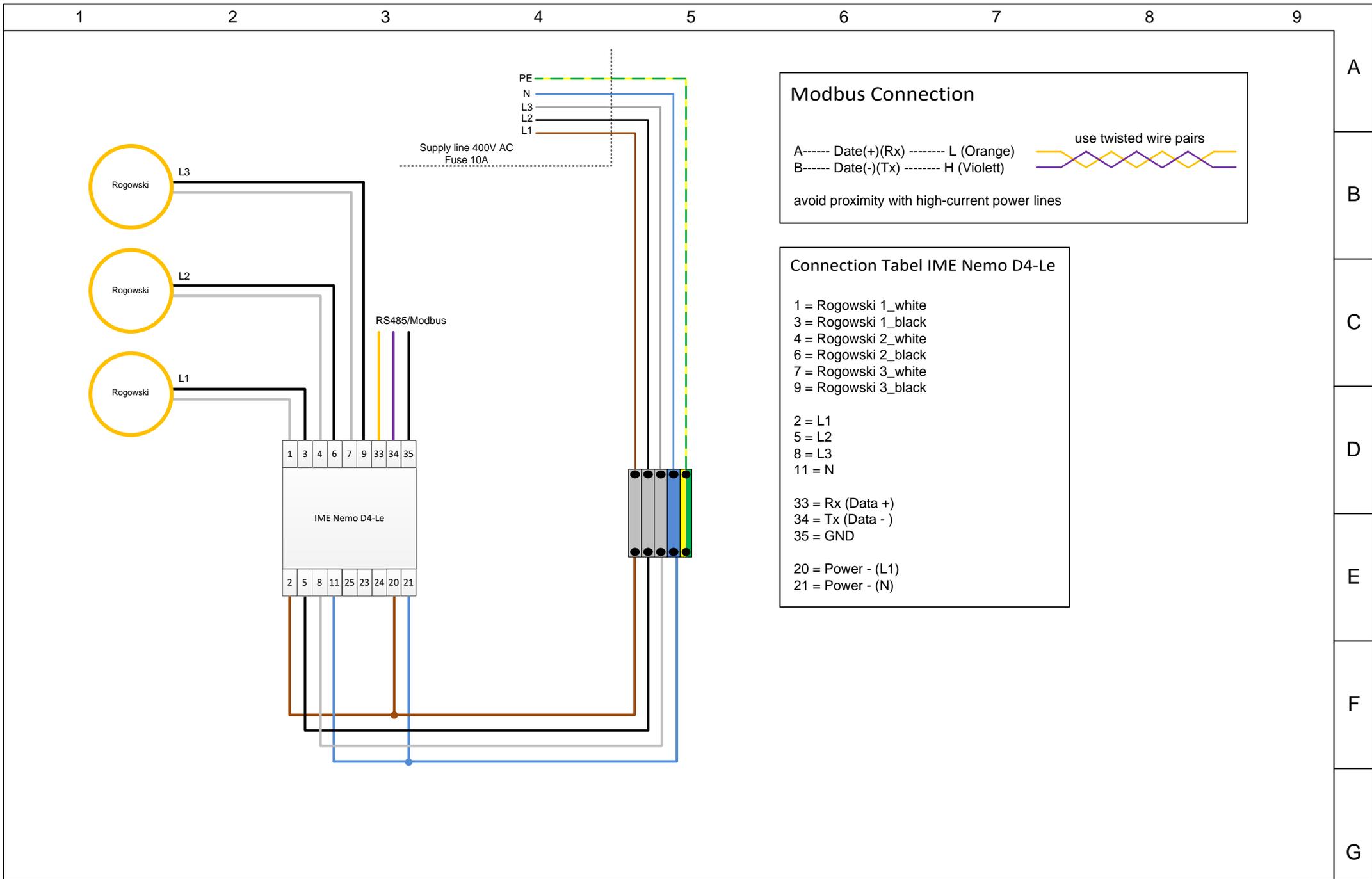




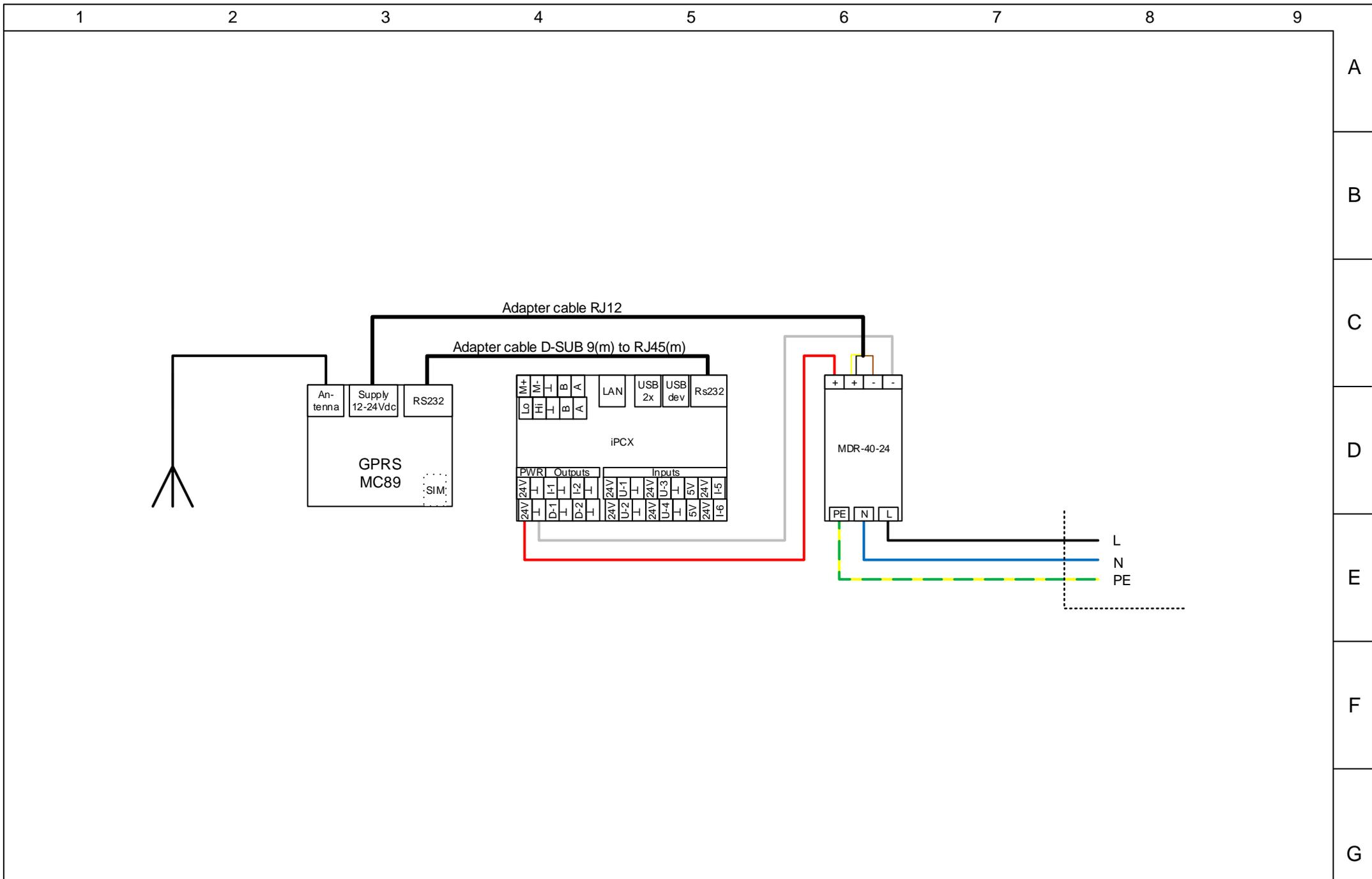
Examples for Output/Input terminals





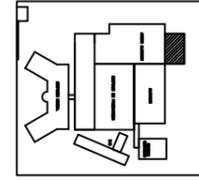




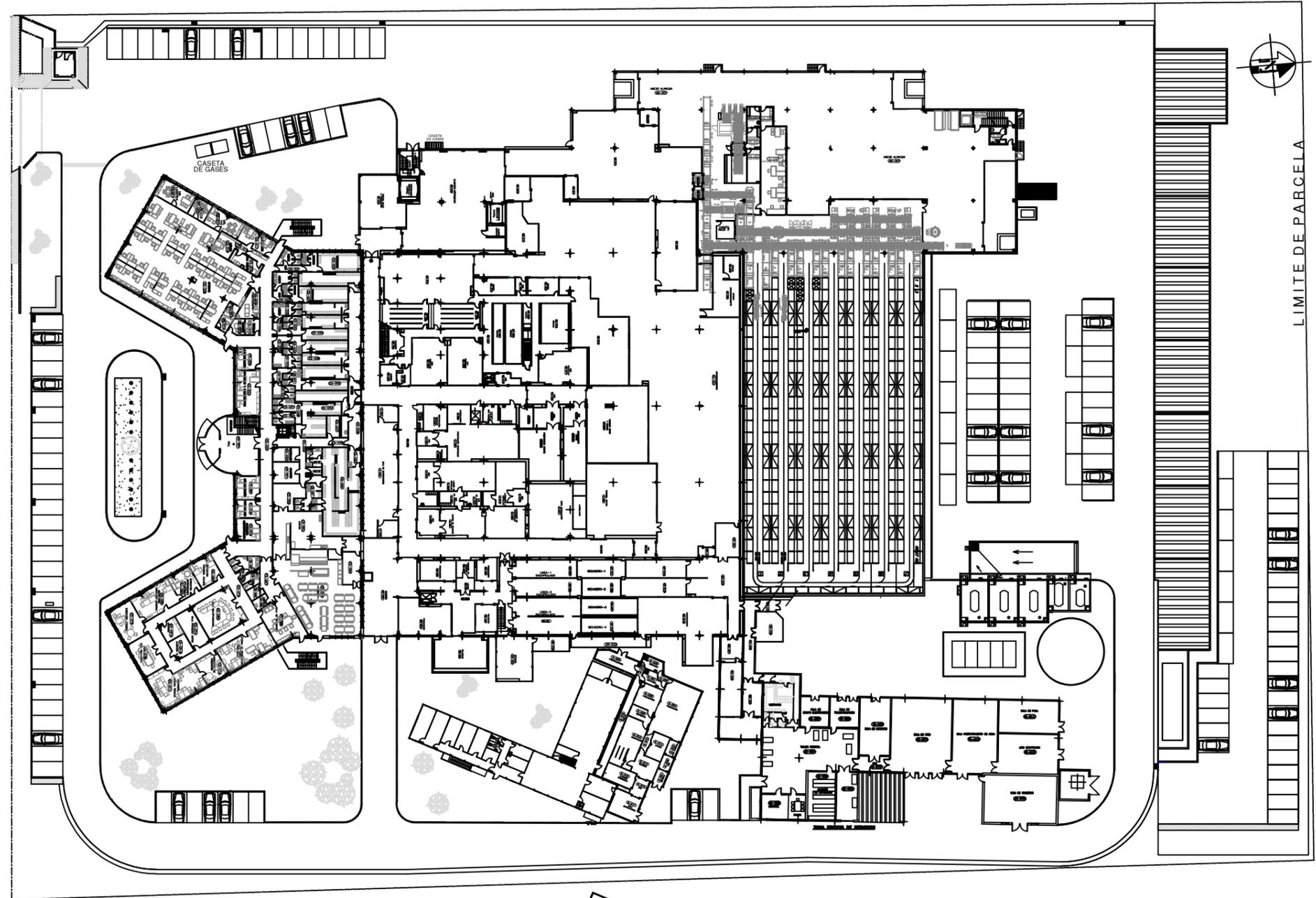
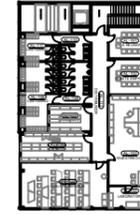




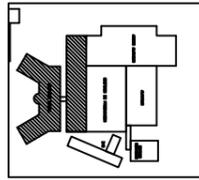
PLANTA 1ª ALMACÉN (PLANTA CLAVE)



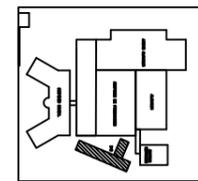
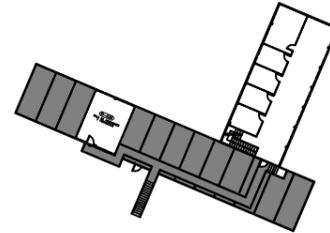
PLANTA PRIMERA



PLANTA PRIMERA (PLANTA CLAVE)

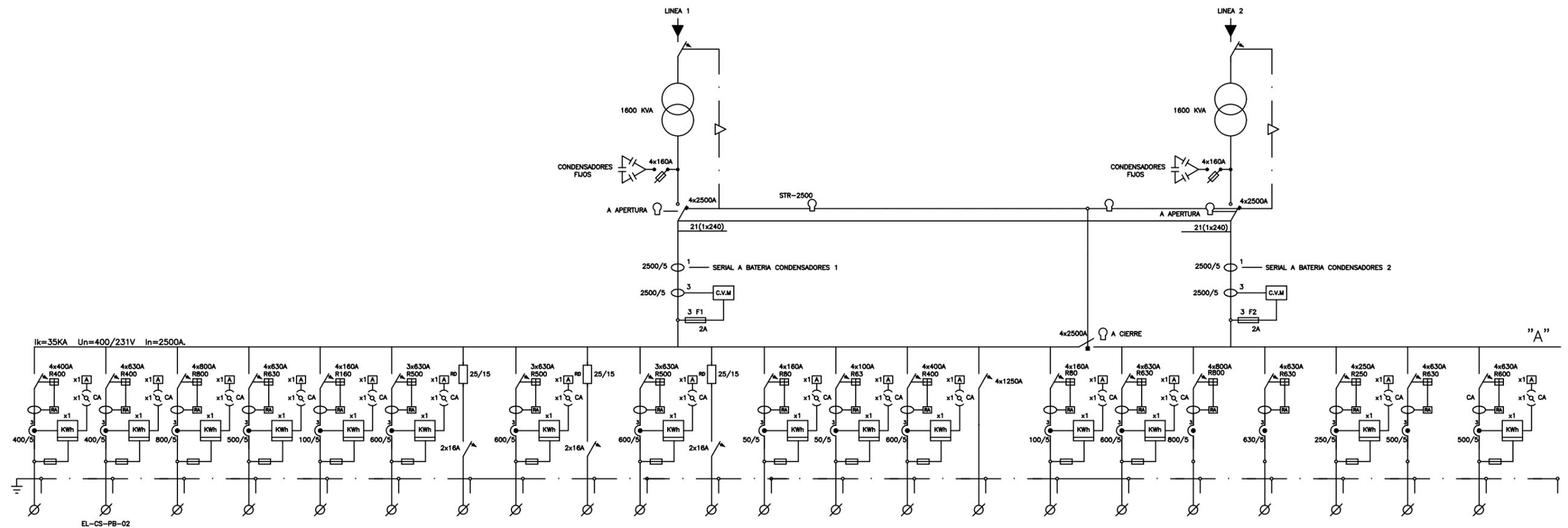


PLANTA 1ª I+D (PLANTA CLAVE)

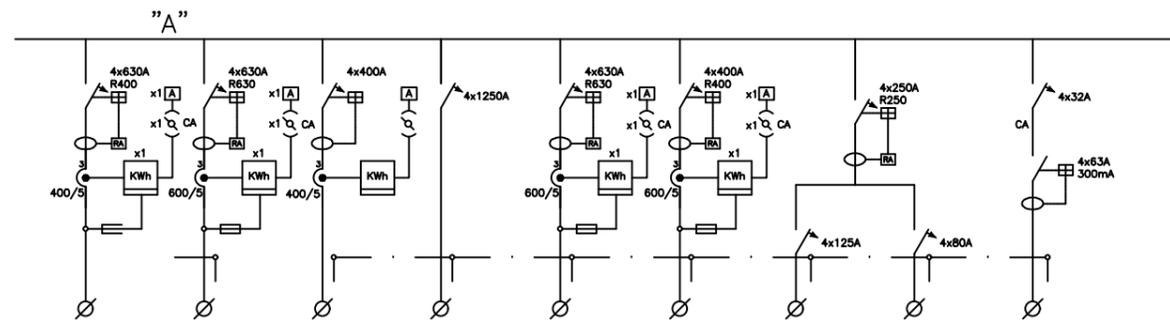


17	Actualización	O.E.C.	T.M.G.	F.M.S.	AGO-16
16	Actualización	J.A.S.	T.M.G.	F.M.S.	MAR-16
15	Actualización	O.E.C.	T.M.G.	F.M.S.	ENE-16
14	Actualización	J.A.S.	T.M.G.	F.M.S.	AGO-15
13	Actualización	M.S.B.	T.M.G.	F.M.S.	ABR-15
12	Actualización	M.S.B.	T.M.G.	F.M.S.	ENE-15
11	Actualización	O.E.C.	T.M.G.	F.M.S.	AGO-14
10	Actualización	O.E.C.	T.M.G.	F.M.S.	MAY-14
09	Actualización	O.E.C.	T.M.G.	M.M.J.	ENE-13
08	Actualización	O.E.C.	T.M.G.	M.M.J.	MAY-12
...	...	...	...	...	...
00	...	O.E.C.	F.M.S.	M.M.J.	MAR-05
Rev.	Descripción	Dibujado	Comprobado	Aprobado	Fecha
Título:		PLANTA GENERAL			
Proyecto:		PLANOS DE PLANTA			
Plano N°:		0000-109-000.17			
Escala:		S/E			
Papel:		DIN-A1			





CIRCUITO	1	11	3	4	5	6	7	8	9	10	2	12	24	13	14	15	16	17	18	
SERVICIOS	EDIFICIO SOCIAL	MOD. EXTER. I+D	PLANTA TECNICA	ALMACEN	EDIFICIO SERVICIOS	ENFRIADORA 1	ENFRIADORA 2	ENFRIADORA 3	CALDERA	AMPLIACIÓN ALMACÉN	EL-CS-PB-02 PB OFICINAS ALA OESTE	BATERIA CONDES. 1	NITROGENO	PESADAS Y SOLIDOS	LIQUIDOS	SEMISOLIDO Y CAPSULAS	ACONDICIONAMIENTO	ALUMBRADO	GRUPO BOMBAS FRIO	
POTENCIA (KW)	175	200	355	248	50	235	235	235	20	50	235	600KVAR		270,58	336,10	270,70	89,20	250	231	
INT. (A)	341,34	390,10	692,43	483,73	97,53	458,37	458,37	458,37	39,01	60	458,37	866,03		530,48	659,13	530,87	174,93	487,63	450,57	
SECCION (mm2)	3(2x185)+1(1x185)+T	3(2x185)+1(1x185)+T	3(2x240)+1(1x240)+T	3(2x150)+1(1x150)+T	3,5x35+T	3(2x95)+T	3(2x95)+T	3(2x95)+T	4x16+T	3,5x35+T	3(2x95)+T	3(3x150)+T	3,5x16	3(2x185)+1(1x185)+T	3(2x185)+1(1x185)+T	3(2x150)+1(1x150)+T	3(2x70)+1(1x70)+T	3(2x185)+1(1x185)+T	3(2x120)+1(1x120)+T	
LONGITUD (m)	7x153	7x193	7x143	115	10	17	18	19	34	10	17	10		120	87	87	108	8	26	
AV %	0,95	1,31	1,32	1,19	0,30	0,33	0,34	0,35	0,62	0,30	0,33	0,29		1,12	1,02	1,02	0,91	0,20	0,42	
SALIDA A CUADRO	C1F	C2F	C3F	C4F	C5F									C6F	C7F	C8F	C9F			

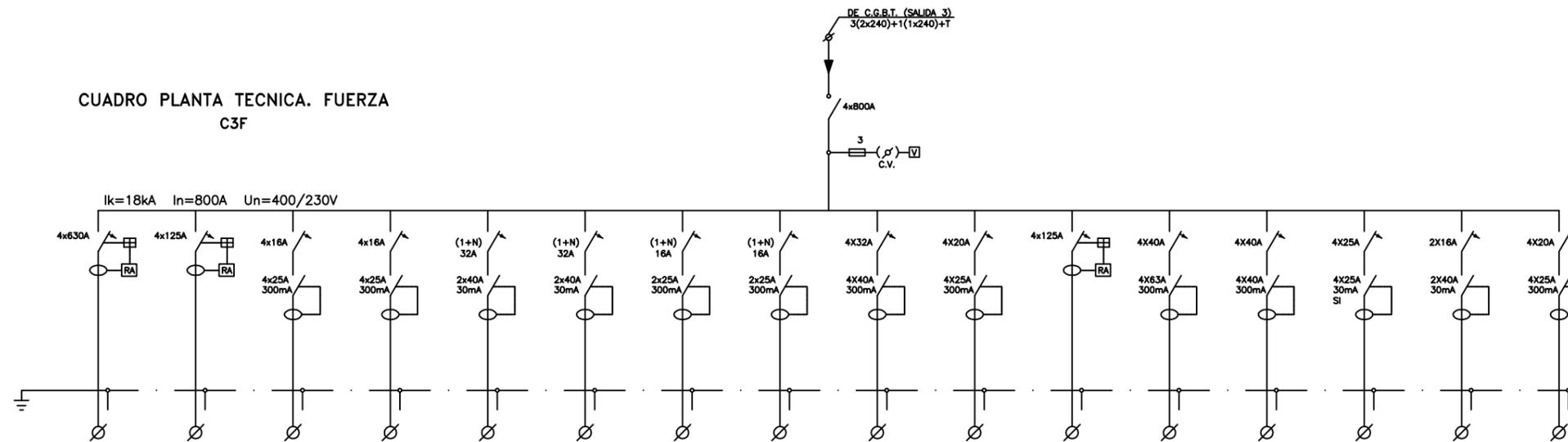


CIRCUITO	19	20	21	22	C11	C22	23	--	26
SERVICIOS	AIRE COMPRIMIDO	CUADRO EMERGENCIA GRUPO ELECTROGENO	C.P.1	BATERIA COND. 2	C.CLIMA SEMISOLIDOS	C.SEDE SOCIAL Planta 1ª RED	CVC PLANTA PILOTO TALLER ZONA EX HUMOS	RESERVA	FUERZA TALLER PETACAS
POTENCIA (KW)	203	400KVA	150	600KVA	400KVA	150	25		
INT. (A)	395,95	577,35	292,58	866,03	577,35	292,58	M/VAC L7 58 59		
SECCION (mm2)	3(1x240)+1(1x120)+T	3(2x150)+1(1x150)+T	3(1x185)+1(1x95)+T	3(3x150)+T	3(2x150)+1(1x150)+T	4(2x120)+T			
LONGITUD (m)	38	9	47	13	9	47			
AV %	0,50	0,25	0,57	0,33	0,25	0,57			
SALIDA A CUADRO									

DOCUMENTO:	PROPIEDAD:
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO	PLANTA FARMACEUTICA
PLANO:	NUMERO:
CUADRO GENERAL DE BAJA TENSION. C.G.B.T. ESQUEMA UNIFILAR	06
ESCALA: S/E	FECHA: MARZO - 2019



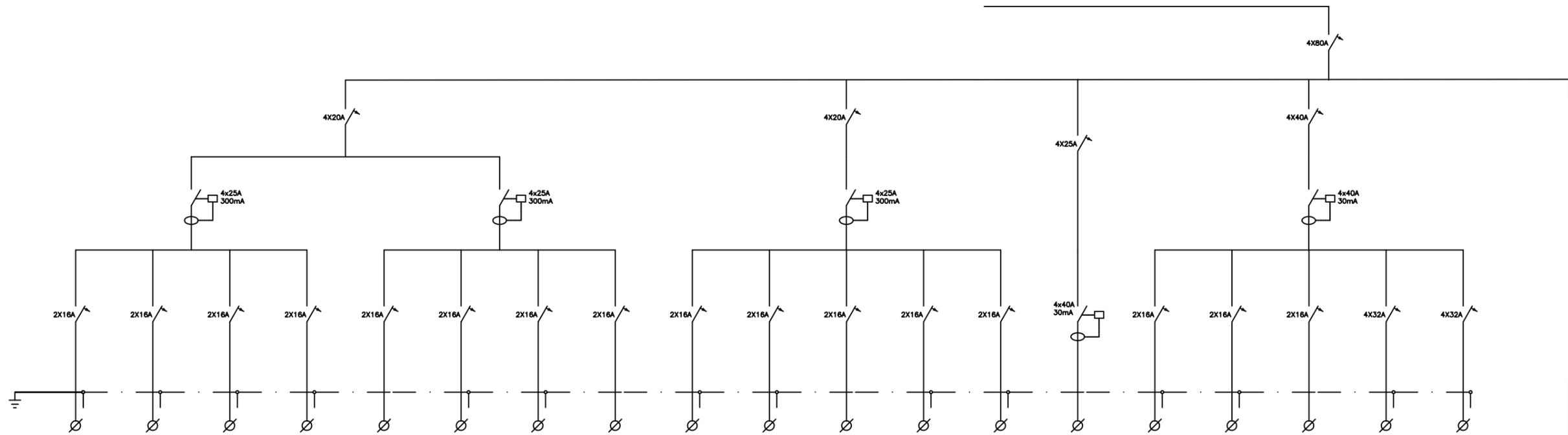
CUADRO PLANTA TECNICA. FUERZA  
C3F



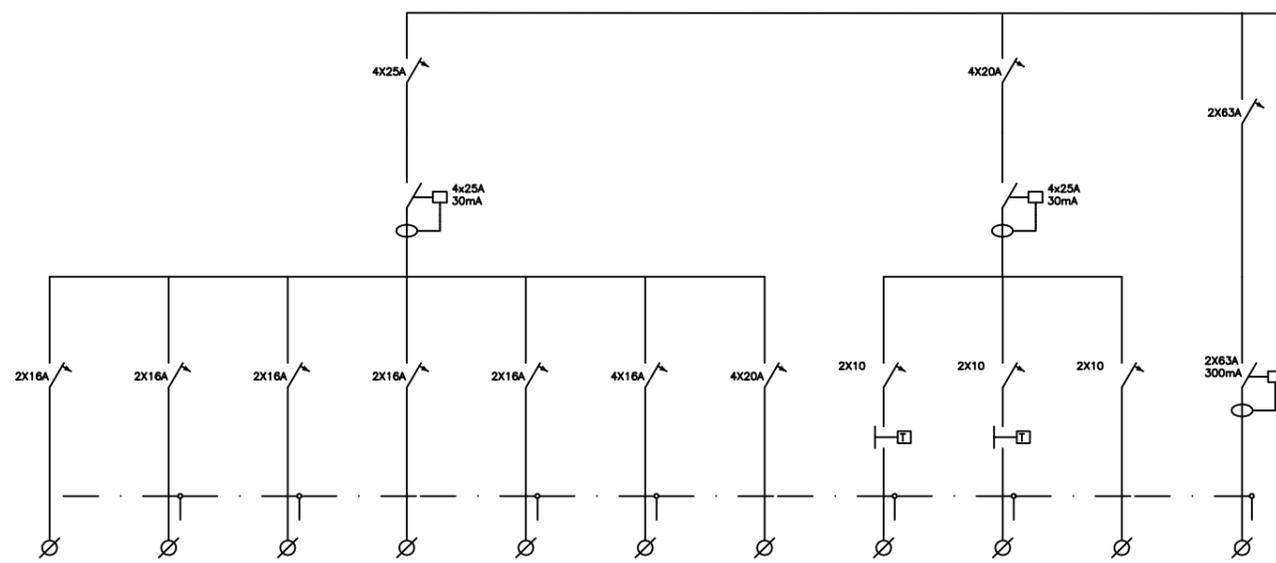
CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SERVICIO	AIRE ACONDICIONADO (CUADRO)	TRATAMIENTO AGUA (CUADRO)	TOMA TRIFASICA EXTRAC. LAVADORAS	RESERVA	GRUPO 1	GRUPO 2	GRUPO 3	ACCESO AGUAS DE SALA	BOMBAS VACIO LIQUIDOS	BOMBAS VACIO NUEVO REACTOR GELATINA	CVC REVISADORAS Y LINEA 3	SISTEMA C.I.P.	EQUIPO BACHILLER	CIRCUITO 1	PUERTA MONOFASICAS SALA BACHILLER	CIRCUITO 3 RESERVA
POTENCIA (kW)	282	60	5		5,2	5,2	2,6				60					
INT. (A)	508,79	108,25	9,81		28,26	28,26	14,13				108,25					
SECCION (mm2)	3(2x1x150)+(1x150)+T	3,5x50+T	5x2,5		3x6	3x6	3x2,5				3,5x50+T					
LONGITUD (m)	25	28	29		36	46	43				28					
AV %	1,58	1,70	1,97		3,42	4,01	4,34				1,70					

DOCUMENTO:		PROPIEDAD:	
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO			
PLANO:			NUMERO:
CUADRO PLANTA TECNICA. FUERZA. C3F ESQUEMA UNIFILAR			7
ESCALA: S/E	FECHA: MARZO - 2019		





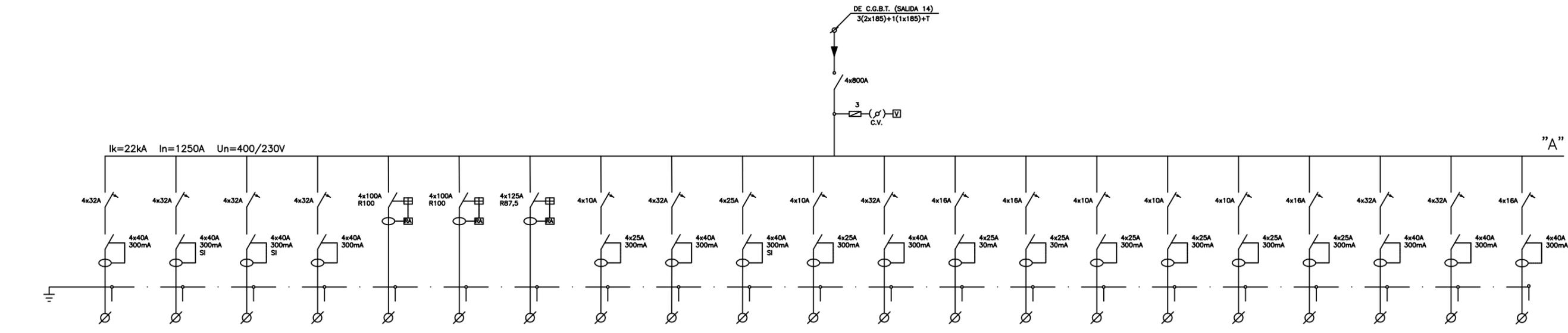
CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
SERVICIO	CL101	CL102	CL103	CL104	CL105	CL106	CL107	CL108	CL001	CL002	CL003	CL004	CL005	CAB.Y EXTRA	PC1	PC2	PC3	GALENICA	GALENICA
POTENCIA (KW)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
INT. (A)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
LONGITUD (m)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
SECCION (mm2)	2x2,5+T	4x2,5+T	2x2,5+T	2x2,5+T	2x2,5+T	4x6+T	4x6+T												
AV %	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---



20	21	22	23	24	24	24	24	25	26	27
P1 ENCHUFES BLANCOS	P2 ENCHUFES BLANCOS	P3 ENCHUFES BLANCOS	P4 ENCHUFES BLANCOS	P5 ENCHUFES BLANCOS	EXTRACTORES	CABINA	L1	L2	L3	SAI HPLC
---	---	---	---	---	---	---	---	---	---	---
---	---	---	---	---	---	---	---	---	---	---
2x2,5+T	2x2,5+T	2x2,5+T	2x2,5+T	2x2,5+T	4x2,5+T	4x6+T	2x1,5+T	2x1,5+T	2x1,5+T	2X16+T
---	---	---	---	---	---	---	---	---	---	---

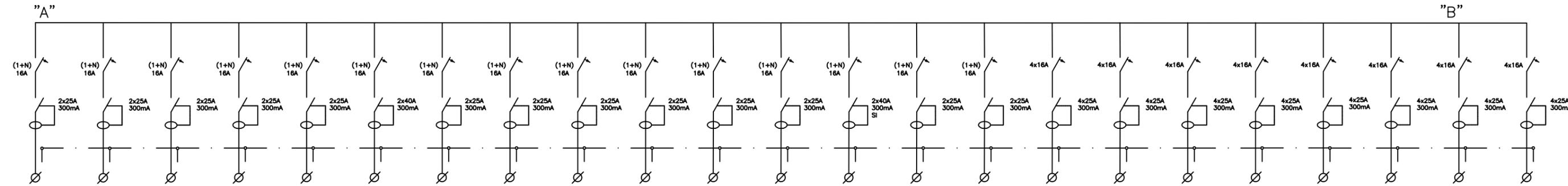
DOCUMENTO:		PROPIEDAD:
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO		
PLANO:	NUMERO:	
CUADRO CASETA EXTERIOR. P. BAJA ESQUEMA UNIFILAR	8	
ESCALA: S/E	FECHA: MARZO - 2019	





CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	--	20	21
SERVICIO	LI-005/1	LI-005/2	LI-LAV. FRASCOS	LI-005/4	LI-006	LI-007/1	LI-007A/1	LI-014/1	LI-014/2	CAPSULAD. FRASCOS	RESERVA	LI-018	LI-020/1	FLUJO CERADORA	LI-021/1	LI-021/2	LI-021/3	LI-022	C. PANEL TACTIL	PLANTA TECNICA	PESTER GOTAS
POTENCIA (KW)	12	12	2	15	55	47	47	1,5	15			15	6	5	2,5	2,5	2,5	5		15	
INT. (A)	23,53	23,53	3,92	29	107,86	92,17	92,17	2,94	29			29	11,77	9,81	4,90	4,90	4,90	9,81		29	
SECCION (mm2)	4x6+T	4x6+T	4x2,5+T	4x6+T	3,5x70+T	3,5x35+T	3,5x35+T	4x2,5+T	4x6+T			4x6+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T		4x6+T	
LONGITUD (m)	55	65	80	60	68	55	45	65	75			57	40	35	25	30	35	87		38	
AV %	2,25	2,47	1,74	2,70	1,86	1,85	1,70	1,46	3,11			2,61	2,09	1,80	1,30	1,36	1,41	2,96		2,08	

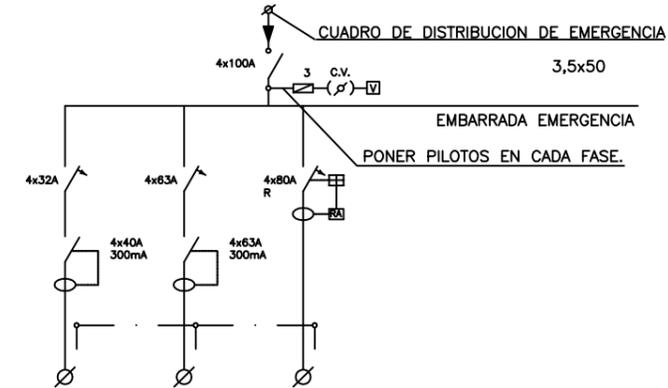
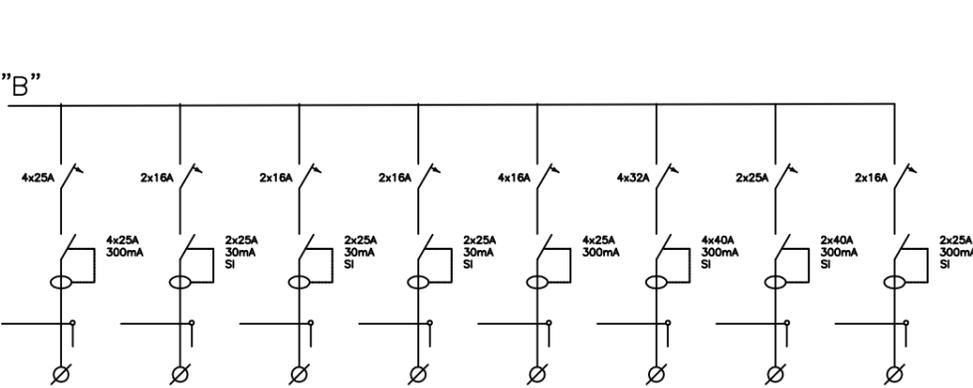
TOMAS DE EQUIPOS



	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
LI-001/005/010/011		LI-008/014/019/020	LI-007A/009/012/013/015	LI-004/007/016/017	LI-021	PASILLOS	PUERTTA 021 LUPA	PUERTTA 017	LI-005/007A008/010	LI-005/007A008/010	LI-002/014/018/019/020	LI-002/014/018/020	LI-007/015/016/017/020/021	LI-007/015/016/017/020/021	CERRADURA	ENCHUFES AUTOC.	LI-005/007A	LI-007/015/016	LI-002	LI-014	LI-019/020	LI-017/021	EISAI AMPOLLAS
2,6	2,6	2,6	2,6	2,6	3,9	2,6		2,6	2,6	2,6	2,6	2,6	2,6	2,6			5	7	5	7	5	5	
15,36	15,36	15,36	15,36	15,36	23,04	15,36		15,36	15,36	15,36	15,36	15,36	15,36	15,36			9,81	13,73	9,81	13,73	9,81	9,81	
3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x4	3x2,5		3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5			5x2,5	5x2,5	5x2,5	5x2,5	5x2,5	5x2,5	
80	45	80	55	55	123		35	80	90	50	55	35	35		72	80	80	50	55	60	70		
1,95	1,54	1,95	1,66	1,66	2,36		1,02	1,91	2,07	1,60	1,66	1,40	1,40			2,81	3,52	2,14	2,74	2,36	2,58		

TOMAS COR. GRAL. 16+F+N+T

T.I.+T.O.

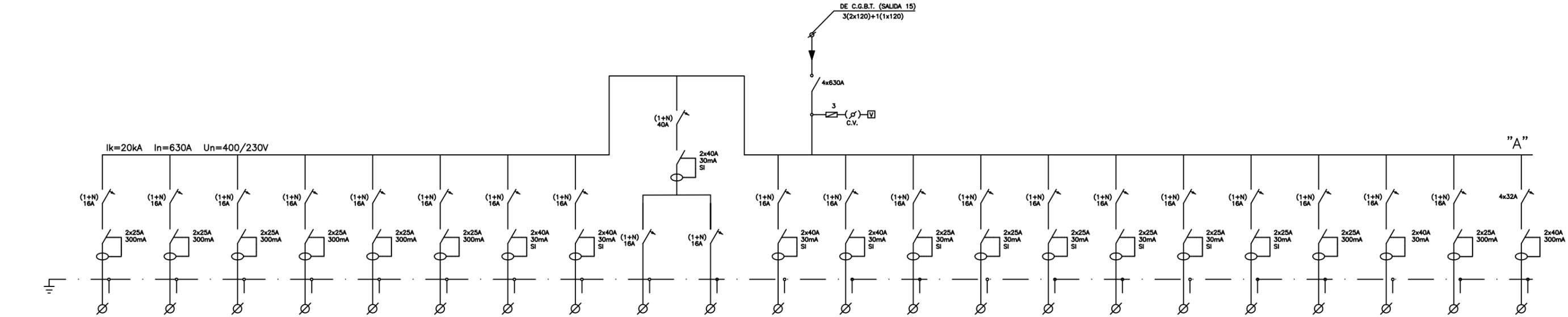


	45	--	--	--	--	--	--
BOSCH KLD,S	PTA.SAS-1/FRASCOS	PTA.SAS-2/FRASCOS	ELECTROVALV. LI	PTAS ENROLL. SAS	AUTOCLAVE FOF5	LLENADO FRASCOS	PTA RAPIDA LI 15A

TUNEL FRESCOS LI	AUTOCLAVE FECEGARI	3
LI-017/1	LI-017/2	TRATAMIENTO DE AGUA
15	10	
29,42	19,61	
4x6+T	4x6+T	3,5x35+T
41	35	
2,17	1,67	

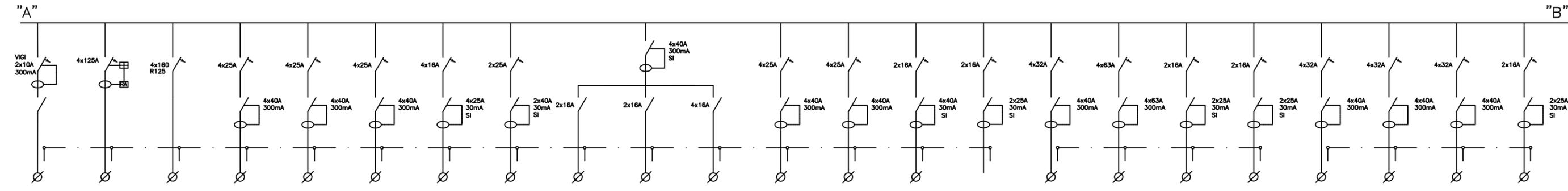
DOCUMENTO:		PROPIEDAD:	
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO			
PLANO:		NUMERO:	
CUADRO LIQUIDOS. FUERZA. C7F ESQUEMA UNIFILAR		9	
ESCALA: S/E	FECHA: MARZO - 2019		





CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	--
SERVICIO	SM-002/005	SM-004/007	SM-009/010/011	SM-012	SM-014	SM-019/020/021 ADF	SM-014-B	SM-014-C	SM-016-ENCAPSUL	SM-014-B (U/V)	SM-014-B	SM-014-C	SM-022-7/SM-41	SM-022-8/SM-41	SM-022-9/SM-03	SM-022-10/SM06	SM-022-11/SM-06	SM-022-12/SM-MAT	SM-023/024/025/026	PG-004	RESERVA	LAVADORA
POTENCIA (KW)	2,6	2,6	2,6	2,6	2,6	2,6	3	3	3	3	3	3	3	3	3	3	3	3	3	2,6	3,9	
INT. (A)	15,36	15,36	15,36	15,36	15,36	15,36	17,72	17,72	17,72	17,72	17,72	17,72	17,72	17,72	17,72	17,72	17,72	17,72	15,36	23,04		
SECCION (mm2)	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x4	3x2,5	3x4		
LONGITUD (m)	40	35	20	20	10	12	30	30	30	30	37	37	37	37	40	40	37	37	41	45		
AV %	3,83	3,48	2,42	2,42	1,72	1,86	2,54	2,54	2,54	2,54	2,89	2,89	2,89	2,89	3,05	3,05	2,89	2,89	3,90	3,98		

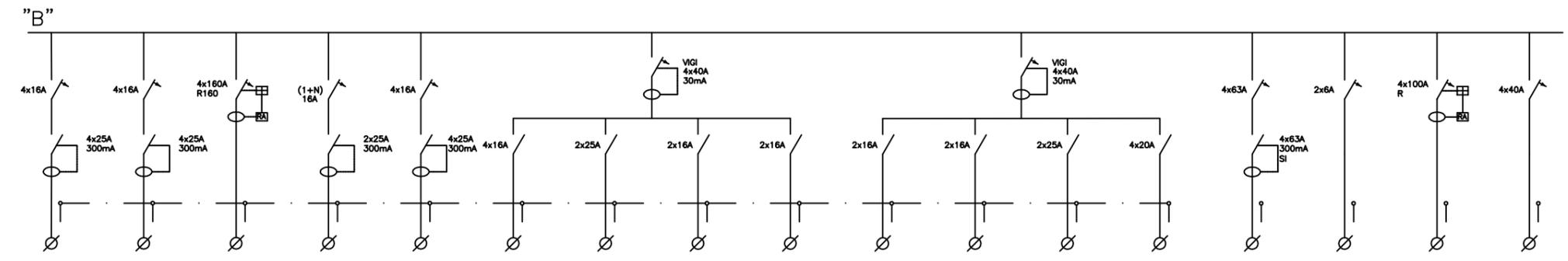
TOMAS GENERALES F+N+T



--	22	23	24	--	26	--	--	--	28	29	--	--	31	32	--	--	34	35 - RESERVA	36	--		
VEDSA	NUEVO REACTOR	SECAD1,2,3,4,DESH1,2	SM-013	SM-014	SM-014-B	SM-014-A	SM-022-3/DEP GEL	U/V1-SM041	U/V2-SM006	T.TRIF-SM006	SM-023-1	SM-024/026	EMPUJ-L1	SM-009-P.RAP	SM-002	SM-003	SM-014A/P.RAP1	SM-014A/P.RAP2	SM-010	SM-011	SM-020 (ADF)	SM-014-A (U/V)
			8	8	6	3	8				7	7			11	16,5			10	10	12,5	2,5
			15,70	15,70	11,77	5,88	15,70				13,73	13,73			21,57	32,36			19,61	19,61	24,51	19,61
			5x2,5	5x2,5	5x2,5	5x2,5	5x2,5				5x2,5	5x2,5			4x6+T	4x10+T			4x6+T	4x6+T	4x6+T	2x2,5+T
			23	20	30+37	40	17				40	35			50	40			30	39	38	37
			1,84	1,74	2,82	1,56	1,63				2,27	2,12			2,04	1,76			1,58	1,75	1,90	1,71

TOMAS GENERALES 3F+N+T

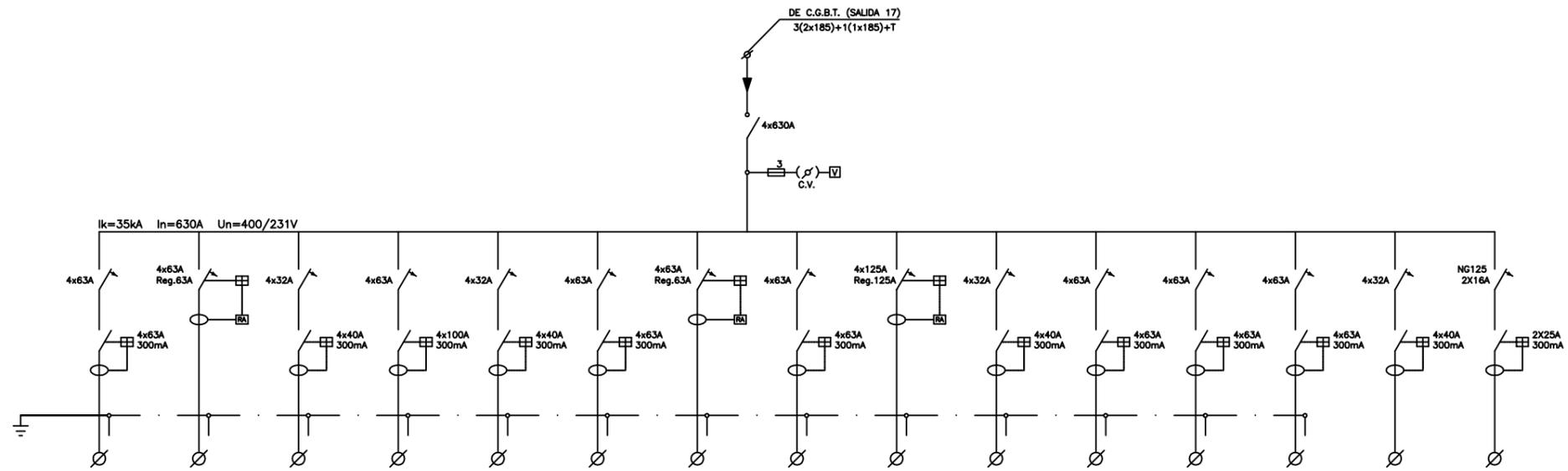
TOMAS EQUIPOS



38	39	40	41	42	--	--	--	--	--	--	--	--	--	--	--	--	
SM-021 (A)	ELEVADOR	SM-022	BASCULA	RESERVA	PUERTAS-L1	PESO	ENCHUFE	EMERGENCIA	ENCHUFE	ENCHUFE	ENCHUFES	SIN USO	LINEA CGB 3y4	CAP.BLANDA	MANIOB.REAC.NUEV	BACHILLER/1000/GEL	AMP./ALM. CAP.
5	3	70	2,6														
9,81	5,88	137,28	15,36														
4x2,5+T	4x2,5+T	3,5x70+T	3x2,5														
45	50	41	50														
2,03	1,89	1,48	4,53														

DOCUMENTO:		PROPIEDAD:	
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO			
PLANO:		NUMERO:	
CUADRO SEMISOLIDOS Y CAPSULAS. FUERZA RED. C8F ESQUEMA UNIFILAR		10	
ESCALA: S/E	FECHA: MARZO - 2019		

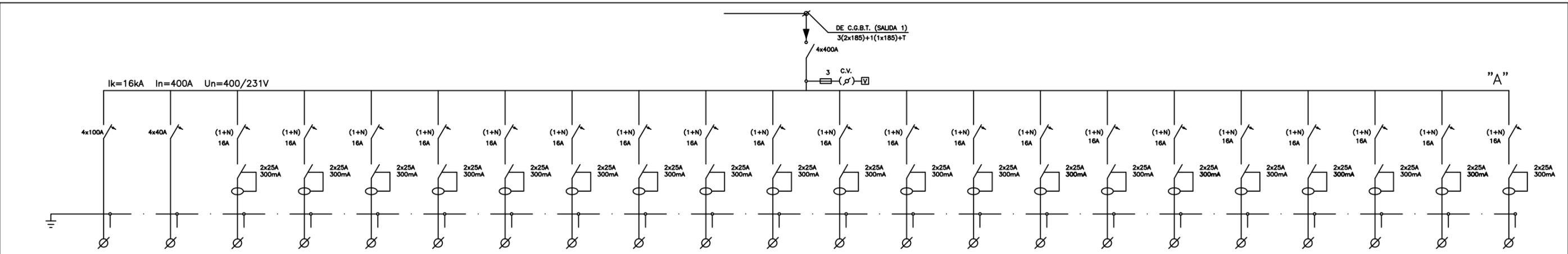




CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SERVICIO	C. ALUMBRADO EDIFICIO SOCIAL	RESERVA	C. ALUMBRADO PLANTA TECNICA	C. ALDO. ALMACEN Y ANEXO ALMACEN	C. ALUMBRADO EDIFICIO SERVICIOS	C. ALDO. PESADAS Y SOLIDOS	C. ALUMBRADO LIQUIDOS	C. ALDO. SEMISOLIDOS Y CAPSULAS	C. ALUMBRADO ACONDICIONAMIENTO	C. ALUMBRADO COCINA	C. ALUMBRADO OFICINAS	RESERVA	C. ALUMBRADO URBANIZACION	RESERVA	CASETA CONTRATA
POTENCIA (KW)	31,39	16,96	9,30	32,07	13,47	25,73	22,11	25,62	31	13,21	18,81		24		
INT. (A)	56,70	30,60	16,78	57,86	24,31	46,42	39,90	46,22	60,10	23,83	33,94		45,58		
SECCION (mm2)	3,5x70+T	3,5x50+T	3,5x25+T	3,5x70+T	4x6+T	3,5x50+T	3,5x35+T	3,5x35+T	3,5x50+T	3,5x35+T	3,5x50+T		4x16+T		
LONGITUD (m)	153	193	145	115	9	120	83	83	105	172	199		9		
AV %	0,97	0,93	0,80	0,79	0,43	0,89	0,79	0,88	0,93	0,93	1,04		0,35		

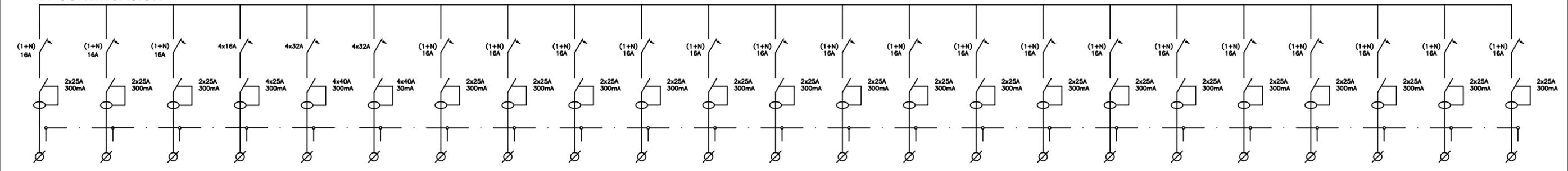
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PLANO:			NUMERO:
CUADRO DISTRIBUCION ALUMBRADO ESQUEMA UNIFILAR			11
ESCALA: S/E	FECHA: MARZO - 2019		





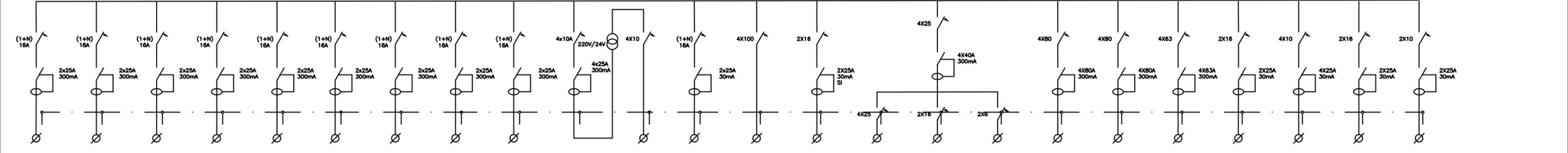
CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
SERVICIO	C. COCINA	CUADRO PROCESO DATOS (KVA) - CS1	ASEO MUJERES SECAMANOS	ASEO HOMBRES SECAMANOS	ASEO MOD. 3-4 SECAMANOS	ASEO MOD. 1-2 SECAMANOS	ASEOS C7	ASEOS C8	ASEOS C9	ASEOS C10	ASEOS C11	ASEOS C12	RESERVA	CENTRALITA	ASEO VESTUARIOS HOMBRES	ASEO VESTUARIOS MUJERES	SALA PAUSA MAG. BEB. 1	SALA PAUSA MAG. BEB. 2	SALA PAUSA MAG. BEB. 3	SALA PAUSA MAG. BEB. 4	ASEO PAUSA SECAMANOS	ASEO MUJERES SECAMANOS	
POTENCIA (KW)	40	20KVA	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	2,2	---	2	2,2	2,2	2	2	2	2	2,2	2,2	
INT. (A)	72,17	28,90	11,25	11,25	11,25	11,25	11,25	11,25	11,25	11,25	11,25	11,25	---	10,23	11,25	11,25	10,23	10,23	10,23	10,23	10,23	11,25	11,25
SECCION (mm2)	3,5x25+T	4x8+T	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	---	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)
LONGITUD (m)	36	56	42	55	52	24	24	25	28	20	16	16	---	7	17	19	41	41	41	31	26	37	
AV %	1,59	3,03	2,51	2,99	2,88	1,84	1,84	1,88	1,99	1,69	1,55	1,55	---	1,18	1,58	1,65	2,33	2,33	2,33	2,00	1,92	2,32	
	ES-063	ES-071	ES-029	ES-030	ES-032	ES-032	ES-033	ES-033	ES-041	ES-041	ES-037	ES-037	ES-045	ES-050	ES-053	ES-057	ES-060				ES-061	ES-068	

"A" CONTINUACION



	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
ASEO HOMBRES SECAMANOS		ASEO OF. HOMBRES SECAMANOS	ASEO OF. MUJERES SECAMANOS	SEGURIDAD	RESERVA REGISTRO EXTERIOR	EQUIPOS INFORM. GARANTIA CALIDAD	PASILLOS. AIRE DESPO LIQUIDOS	PASILLOS. AIRE DESPO LIQUIDOS	T.CORRIENTE C31	T.CORRIENTE C32	T.CORRIENTE C33	T.CORRIENTE C34	RACK	T.CORRIENTE C36	T.CORRIENTE C37	T.CORRIENTE C38	T.CORRIENTE C39	T.CORRIENTE C40	T.CORRIENTE C41	T.CORRIENTE C42	T.CORRIENTE C43	T.CORRIENTE C44	T.CORRIENTE C45
	2,2	2,2	2,2	2	6		2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6
	11,25	11,25	11,25	3,39	10,82		15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36
	3(1x4)	3(1x4)	3(1x4)	4x2,5+T	4x6+T		3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)
	35	41	41	158	154		42	11	51	46	41	23	15	16	27	27	19	19	25	25	56	56	65
	2,25	2,47	2,47	2,36	2,67		2,79	1,43	3,19	2,97	2,75	1,96	1,61	1,65	2,14	2,14	1,78	1,78	2,05	2,05	3,41	3,41	3,80

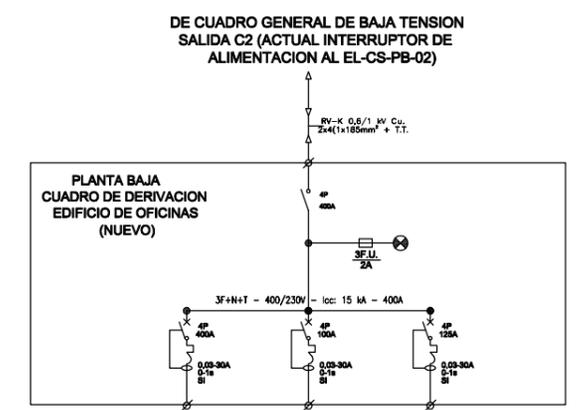
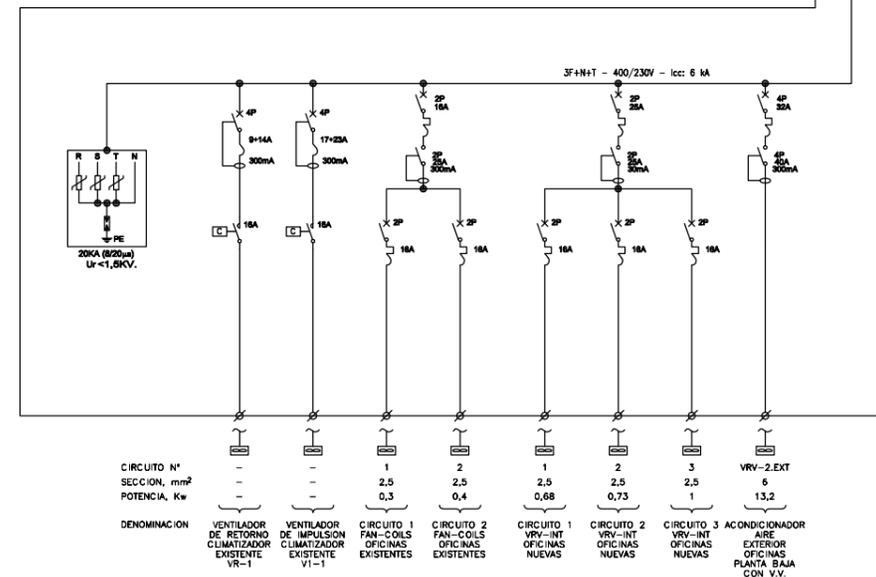
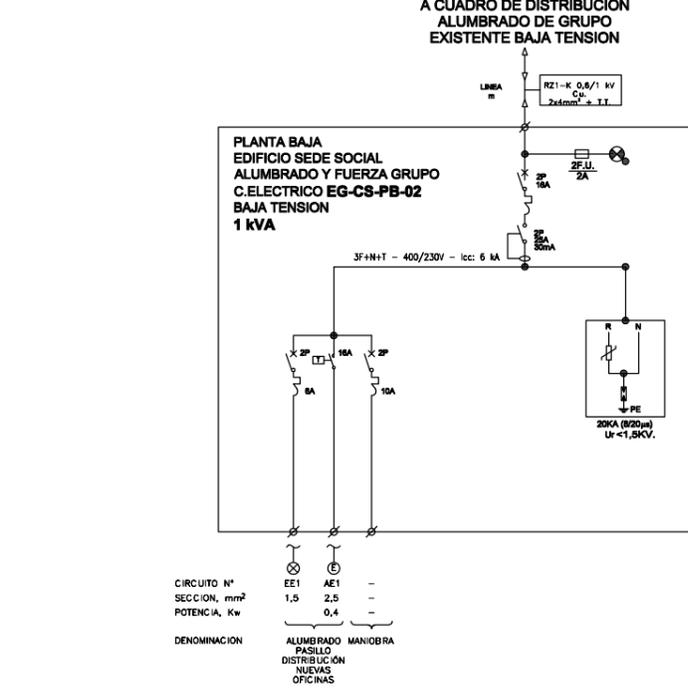
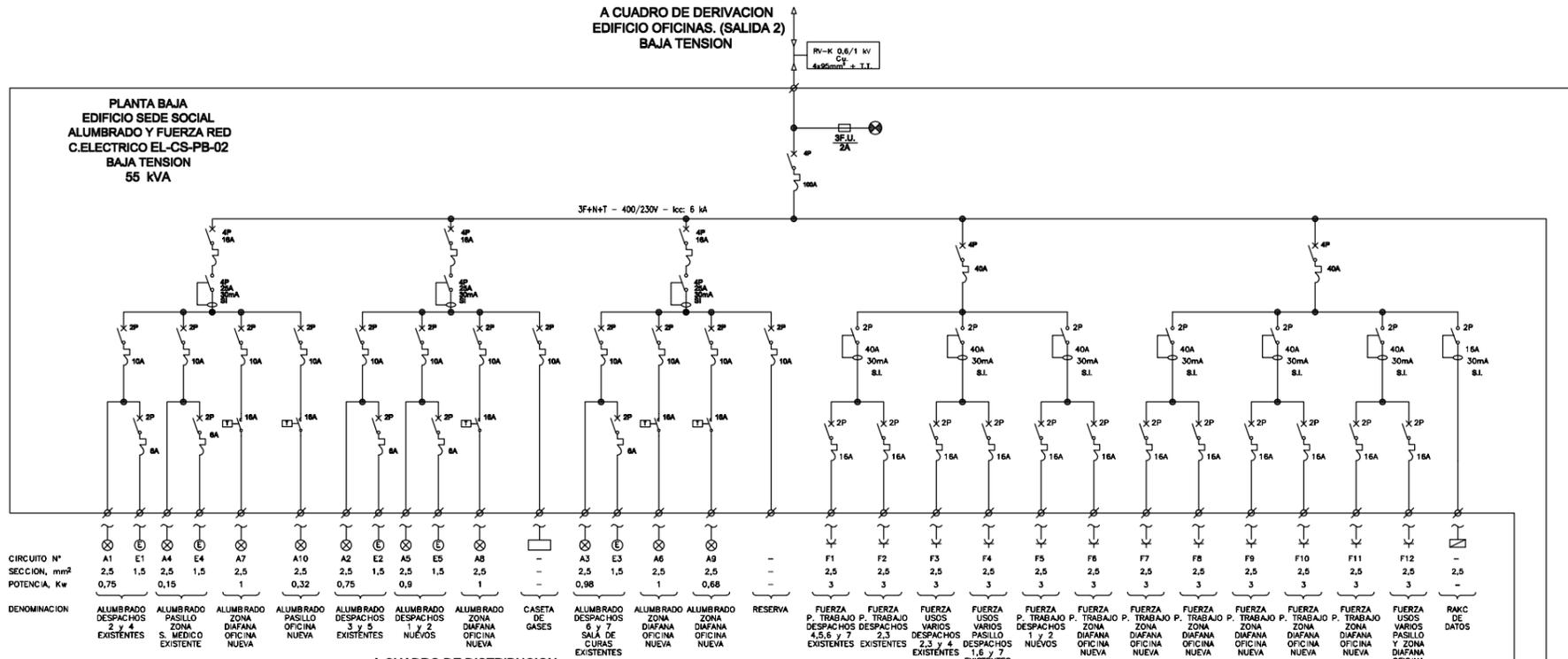
"B" CONTINUACION



	46	47	48	49	50	51	52	53	54	55	56	57	58	A CC N2 SA	FUENTE	DEPURADORA	XXXX	58	COCINA	MODULOS PREFABRICADOS	FAN COIL SALA PAUSA	CUARTO CLIMATIZAC. CUARTO SERVIDORES	ANTITABACO SERVIDORES	A CC SALA
T.CORRIENTE C46		T.CORRIENTE C47	T.CORRIENTE C48	T.CORRIENTE C49	T.CORRIENTE C50	T.CORRIENTE C51	T.CORRIENTE C52	T.CORRIENTE C53	T.CORRIENTE C54		CORREDERA HALL CRISTAL	RESERVA	RESERVA	---	---	---	---	LAVAVAJILLAS COCINA	---	---	---	---	---	
	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6		1,96	---	---	---	---	---	---	---	---	---	---	---	---	
	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36	15,36		1,96	---	---	---	---	---	---	---	---	---	---	---	---	
	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)	3(1x4)		5x2,5	---	---	---	---	---	---	---	---	---	---	---	---	
	65	76	76	59	59	52	52	54	54		17	---	---	---	---	---	---	---	---	---	---	---	---	
	3,80	4,28	4,28	3,54	3,54	3,23	3,23	3,32	3,32		1,03	---	---	---	---	---	---	---	---	---	---	---	---	

DOCUMENTO:		PROPIEDAD:
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO		
PLANO:	NUMERO:	
CUADRO EDIFICIO SOCIAL FUERZA. C1F	12	
ESQUEMA UNIFILAR		
ESCALA: S/E	FECHA: MARZO - 2019	





CIRCUITO N°	SECCION, mm²	POTENCIA, Kw	DENOMINACION
1	2x4(1x95mm²)+T	173,91	PLANTA FIOTO EL-CS-P1-PIL
2	4(1x95mm²)+T	58,00	CUADRO EDIFICIO OFICINAS
---	---	---	CUADRO SEC. OBRAS

#### LEYENDA:

- CARACTERISTICAS TECNICAS DE LA LINEA DE ACOMETIDA AL CUADRO ELECTRICO.
- FUSIBLES.
- INTERRUPTOR DIFERENCIAL.
- INTERRUPTOR AUTOMATICO DISYUNTOR.
- ELEMENTO TERMICO.
- ELEMENTO MAGNETICO.
- ELEMENTO DIFERENCIAL.
- TELERRUPTOR.
- PILOTO DE SEÑALIZACION.
- RECEPTOR DE ALUMBRADO EMERGENCIA.
- ALUMBRADO DE EMERGENCIA.
- TOMA CORRIENTE FUERZA, F+N+T, 16A-250V.
- EQUIPO ELECTRICO.
- BORNE.
- VIA DE CHISPAS DE PROTECCION CONTRA SOBRETENSIONES.
- VARISTOR DE PROTECCION CONTRA SOBRETENSIONES.

#### EL-CS-COM-P1-01-01

NUMERO DE ORDEN DEL CUADRO ELECTRICO

NUMERO DE ORDEN DEL CUADRO ELECTRICO DE LA LINEA PLANTA

SITUACION DEL CUADRO ELECTRICO:

- PB: PLANTA BAJA
- P1: PLANTA PRIMERA
- C2: PLANTA CUBIERTA

TIPO DE SERVICIO:

- DG: CUADRO GENERAL
- CS: CUADRO SECUNDARIO
- CT: CUADRO TERCARIO

TIPO DE INSTALACION:

- EL: ALIMENTACION DE RED
- EG: ALIMENTACION DE GRUPO
- SA: ALIMENTACION DE SAI

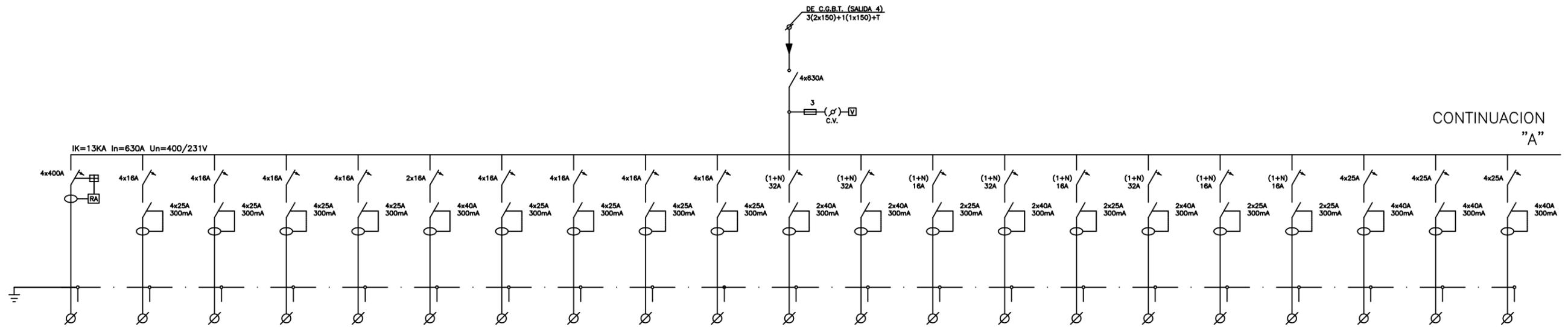
**NOTAS:**

- 1.- LOS CUADROS ELECTRICOS ESTARAN DIMENSIONADOS CON UN 25% DE ESPACIO DE RESERVA.
- 2.- TODAS LAS ALIMENTACIONES QUE PARTEN DEL CUADRO GENERAL DE DISTRIBUCION DE BAJA TENSION IRAN EQUIPADAS CON EL CONDUCTOR DE PROTECCION "PE" CORRESPONDIENTE A LA SECCION DE FASE DE SU PROPIA SALIDA.

<b>DOCUMENTO:</b>	<b>PROPIEDAD:</b>
<b>ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO</b>	
<b>PLANO:</b>	<b>NUMERO:</b>
<b>C. ALUMBRADO Y FUERZA. EDIF. SEDE SOCIAL. EL-CS-PB-02 ESQUEMA UNIFILAR</b>	<b>13</b>
<b>ESCALA:</b> S/E	<b>FECHA:</b> MARZO - 2019

EDS. ESQUEMAS UNIFILARES CUADROS ALUMBRADO Y FUERZA PLANTA BAJA EL/EG-CS-PB-02 EDS.EL.02.01

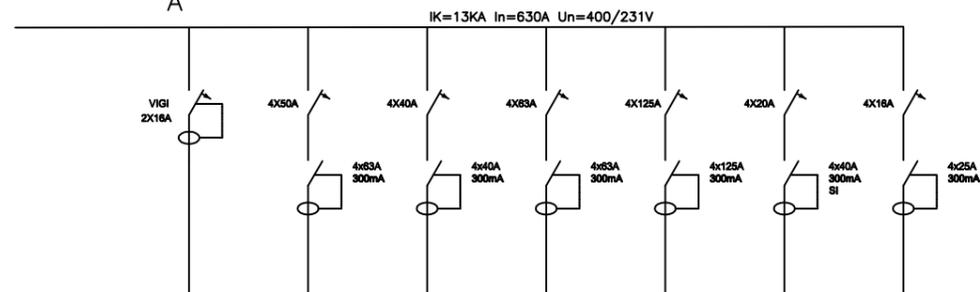




CONTINUACION "A"

CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
SERVICIO	C. MANUTENCION ALMACEN	PUERTA PEQUEÑA	MAQUINA 1 CARGAD. BATERIAS	MAQUINA 2 RETRACTIL. PALETS	BASCULA	APILADOS PALETS PUERTA RAPIDA ALM	MUELLE 1	MUELLE 2	MUELLE 3	MUELLE 4	ENCHUFES ALMACEN	ENCHUFES ALMACEN	GRUPO 3 ALMACEN	GR. 1 ANEX. ALMAC.	GR. 2 ANEX. ALMAC.	ENCHUFES C 1NU	ENCHUFES C2 NUEVO	MODUMAG	GR. 1 ANEX. ALMAC.	GR. 2 ANEX. ALMAC.	PUERTA MUELLE
POTENCIA (KW)	200		2	2	2	2	1,1	1,1	1,1	1,1	5,2	5,2	2,6	2,6	2,6	5,2		-	8,2	8,2	
INT. (A)	360,84		3,61	3,61	3,61	3,61	1,98	1,98	1,98	1,98	28,26	28,26	14,13	14,13	14,13	28,26				14,79	14,79
SECCION (mm2)	3(1x240)+1(1x120)+T		4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	4x2,5+T	3x6	3x6	3x4	3x4	3x4	3x4				4x4+T	4x4+T
LONGITUD (m)			54	52	39	42	58	52	46	40	65	65		50	66	64				48	73
AV %	1,19		1,67	1,86	1,54	1,57	1,48	1,45	1,42	1,39	4,99	4,99	2,95	3,39	4,09	4,93				2,29	2,86
							PUERTA 1Y	PUERTA 2Y	PUERTA 3Y	PUERTA 4Y											

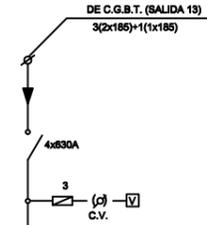
CONTINUACION "A"



CIRCUITO	22	23	24	25	26	27	28
SERVICIO	PROYECTOR	FUERZA 5	FUERZA 6	AUTO COMPACTADOR	C.S. EXCLUSIVA ACONDICIONAMIENTO	MARCHENISI LINEA AMPOLLAS	C. CALIDAD AREA MUESTREO
POTENCIA (W)							
INT. (A)							
LONGITUD (m)							
SECCION (mm2)							
AV %							

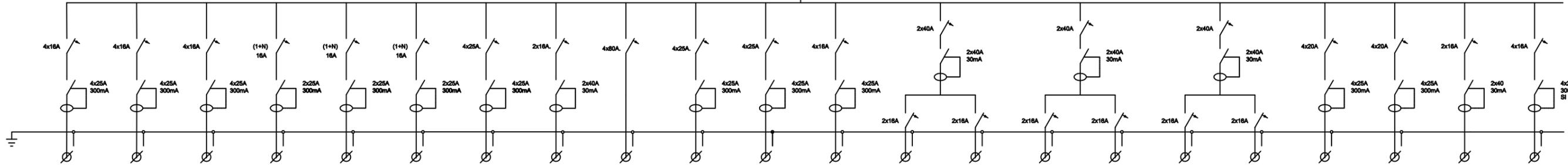
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ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO		
PLANO:	NUMERO:	
CUADRO ACOND. ALMACEN. FUERZA. C4F ESQUEMA UNIFILAR	14	
ESCALA: S/E	FECHA: MARZO - 2019	





CONTINUACION "A"

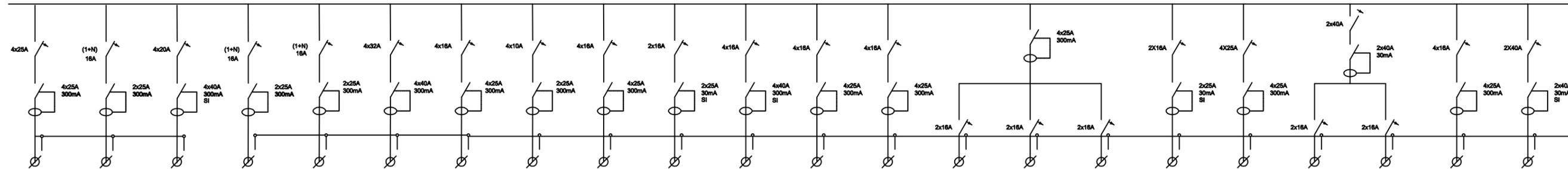
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CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SERVICIO	P-001/003/004 mat prima y cabinas	P-005/011 cabinas pesadas/p.anrollable	RESERVA	P-001/003/004-1 mat prima y cabinas	P-001/003/004-2 mat prima y cabinas	P-005/008/011-1 cabinas	puertas ENR pasillo y gotas	usos varios	tomas trifasicas	C.S. PLANTA PRIMERA	revisadora maquina L7	tomas trifasicas	usos varios L17	usos varios lavadero	empujadores secadero	empujadores secadero	perlanas secadero	perlanas secadero	SO-012-3 steave	SO-012-4 contadora	bases	SO-012-5 Inducion
POTENCIA (KW)	6	4		2,8	2,8	2,8	2,8	2,8	2,8		10,5	7,5	-	-	-	-	-	-	4	3		2
INT. (A)	11,77	7,84		15,38	15,38	15,38	15,38	15,38	15,38		20,59	14,71	-	-	-	-	-	-	7,84	5,88		3,82
SECCION (mm2)	5x2,5			3x2,5	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5		4x8+T	4x4+T	-	-	-	-	-	-	5x2,5+T	5x2,5+T		5x2,5+T
LONGITUD (m)																						
AV %																						

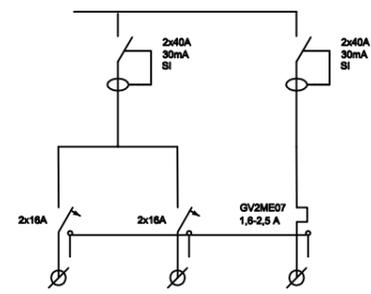
CONTINUACION "A"

CONTINUACION "B"



18	19	20	21	22	23	24	PG-001	dosificadora	puerta rapida 2 sala revision L7	P-002-2 posicionadora	P-002-3 transporte	P-002-4 to trifasica	SO-010 TMA-1	SO-010 TMA-2	SO-010 PUERTA	PUERTA RAPIDA SALA REVISION L6	empujamiento p baja maquina L7	usos varios c1	usos varios c2	tomas trifasicas	puertas rapidas 1 y 2
SO-001 montacargas	P-011 bascula	otarradora gotas clara	P-001/002/010 SAS PALETS	SO-002/003 peso mat prima	SO-013 231 enchufes SS-107 reactor 2000V	gotas viejas															
3			2,8	15,38						1	1	1									
5,88										1,98	1,98	1,98									
5x2,5+T			3x2,5																		

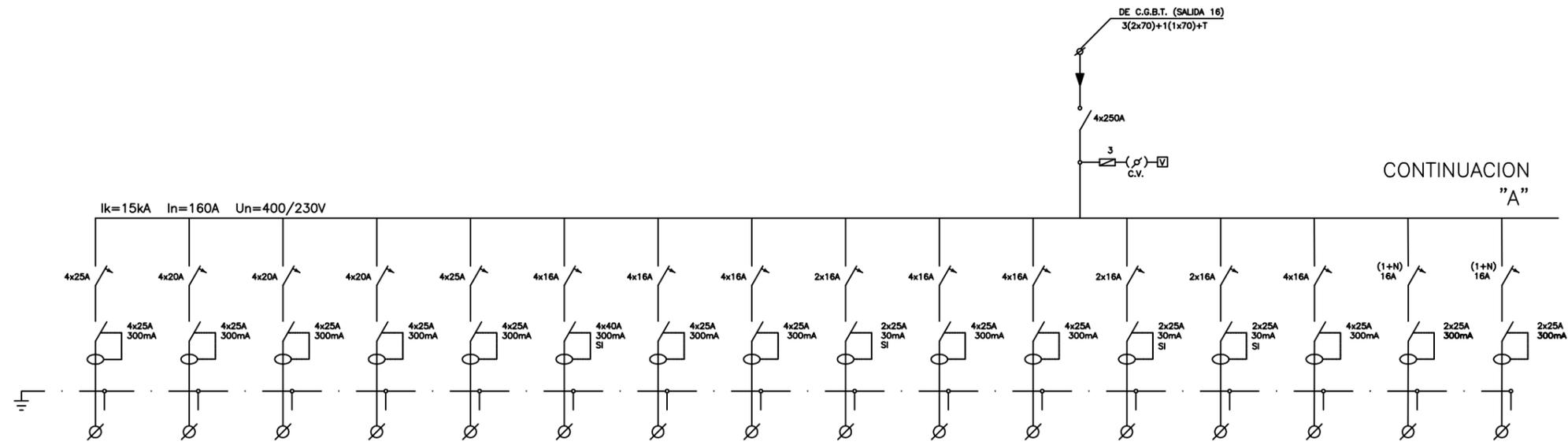
CONTINUACION "B"



usos varios pasillo	usos varios pasillo	bomba extractor hueco ascensor

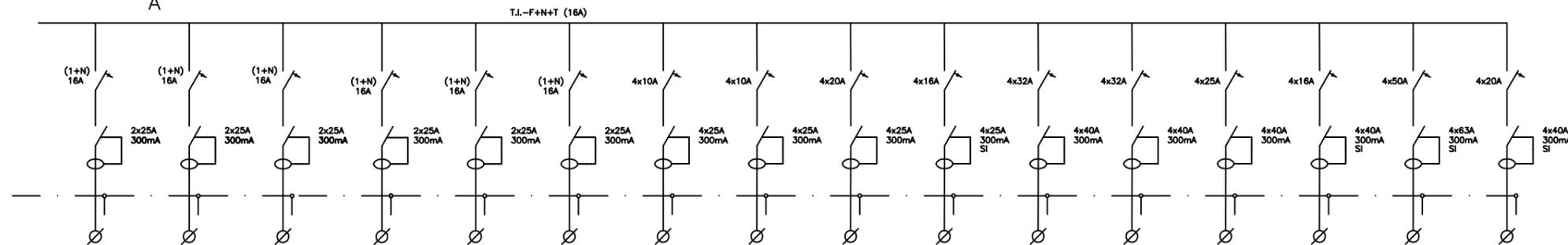
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ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO			
PLANO:		NUMERO:	
CUADRO PESADAS Y SOLIDOS. FUERZA. C6F ESQUEMA UNIFILAR		15	
ESCALA: S/E	FECHA: MARZO - 2019		





CIRCUITO	1	2	3	4	5	6	7	8	9	10	11	12	RSV	13	14
SERVICIO	AC-001/1 ESTUCHADORA IMA	AC-001/2 ESTUC. MARCHESINI	AC-001/3 LINEAS ORALES	AC-001/4 MANUAL AMPOLLAS	AC-001/5 RETRACTIL SOCO	AC-001/6 UHLMANN	T.I.-1/2 BLISTER	T.I.-3/4 PARED ALMACEN	CARGADOR CARRETTILLA	T.I.-5/6 ARMARIO TALLER	T.I.-7/8 VISOMAT SM 5 Y 6	T.I.-9/10 UV 1 SMO47	RESERVA	T.I.-1/2/3/4/5-1 BLISTER IMA	T.I.-1/2/3/4/5-2 BLISTER IMA
POTENCIA (KW)	10	10	10	10	10	2	3,4	3,4		3,4	3,4			2,6	2,6
INT. (A)	19,61	19,61	19,61	19,61	19,61	3,92	6,68	6,68		6,68	6,68			14,13	14,13
SECCION (mm2)	4x4+T	4x4+T	4x4+T	4x4+T	4x4+T	4x2,5+T	4x2,5+T	4x2,5+T		4x2,5+T	4x2,5+T			3x2,5	3x2,5
LONGITUD (m)	41	27	22	31	42	32	60	59		50	27			55	55
AV %	2,06	1,66	1,53	1,78	2,08	1,20	1,82	1,81		1,67	1,32			4,77	4,77
	TOMAS EQUIPOS						T.I.-3F+N+T (16A)								

CONTINUACION  
"A"



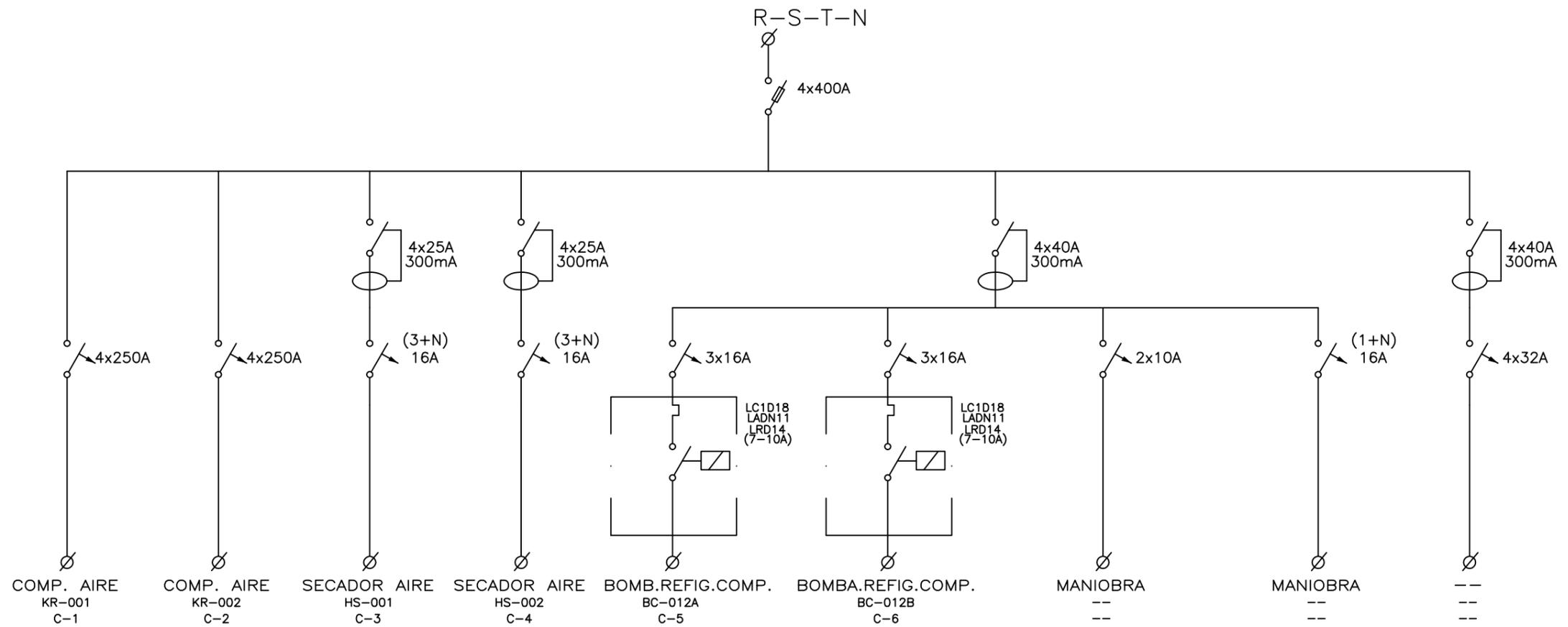
CIRCUITO	15	16	17	18	19	20	21	22	23	24	25	25	25	25	25	
SERVICIO	T.I.-6/7/8/9/10-1 ORDENAD. ETIQUETAS	T.I.-6/7/8/9/10-2 ORDENAD. ETIQUETAS	T.O.-1/2/3-1 DESPACHO	T.O.-1/2/3-2 DESPACHO	AC-001/002 PUERTA TALLER ASEOS	RESERVA	P. ENROLLABLE GRIS Y AZUL	P. CORREDERA GRIS	ETIQUETADO GOTAS PLATO ENTR. SALIDA	ENCHUFES TRIFASICOS SMO47 Y L1 BLISTER	FARMORES	ENCAJADORA ORALES	ENCAJADORA CAPSULAS	PESADORA SMO47	BLISTER SMO47	ESTUCHADORA L1 BLISTER
POTENCIA (W)	2,6	2,6	2,6	2,6	2,6		1	1								
INT. (A)	14,13	14,13	14,13	14,13	14,13		-	-								
LONGITUD (m)	3x2,5	3x2,5	3x2,5	3x2,5	3x2,5		4x2,5+T	4x2,5+T								
SECCION (mm2)	58	58	25	25	160		40	40								
AV %	4,91	4,98	4,98	2,67	4,98		1,09	1,09								

NOTA.-

EL CUADRO SE INSTALARA EMPOTRADO EN LA PARED TRAS UNA PUERTA DE CHAPA DE ACERO INOXIDABLE, CON CERCO PROVISTO DE JUNTA, PARA TENER UNA PROTECCION IP44

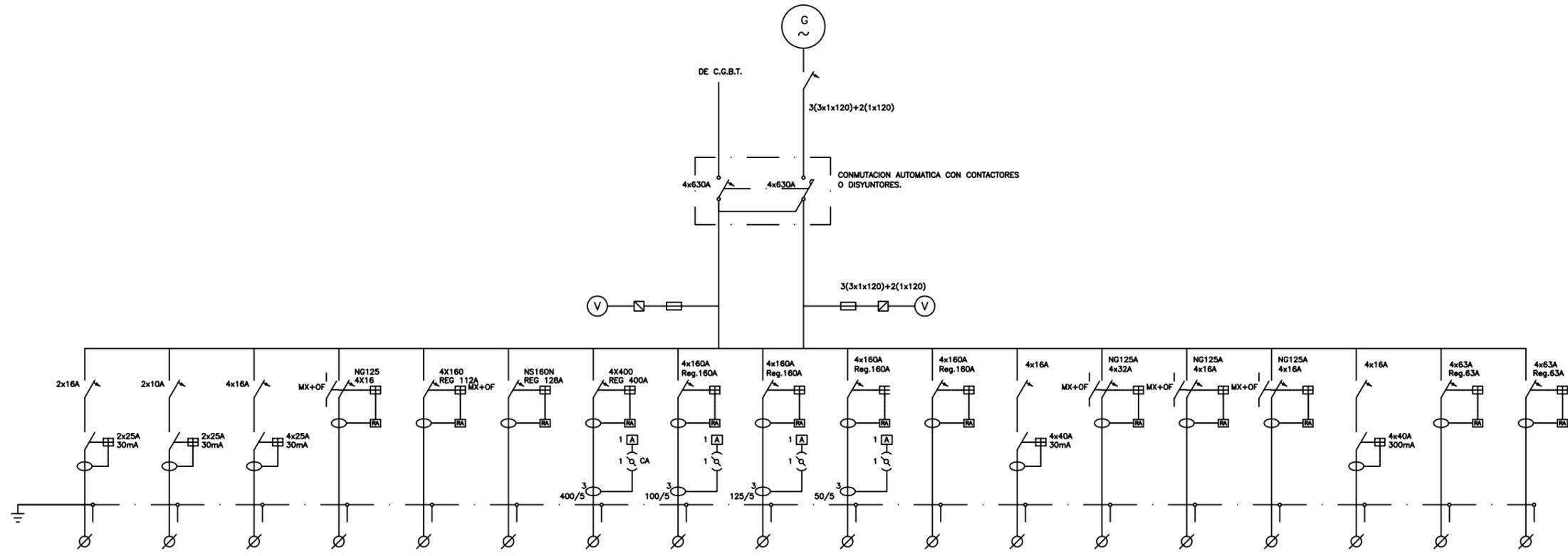
DOCUMENTO:		PROPIEDAD:	
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO			
PLANO:		NUMERO:	
CUADRO ACONDICIONAMIENTO FUERZA. C9F ESQUEMA UNIFILAR		16	
ESCALA: S/E	FECHA: MARZO - 2019		





DOCUMENTO:		PROPIEDAD:
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO		
PLANO:		NUMERO:
CUADRO AIRE COMPRIMIDO ESQUEMA UNIFILAR		17
ESCALA: S/E	FECHA: MARZO - 2019	





CIRCUITO	C-15	C-14	C-7	C-6	C-16	C-5	C-4	C-1	C-2	C-3	C-17	C-8	C-9	C-10	C-11	C-12	C-13	RESERVA
SERVICIO	PROTECCION TRAFOS	PROTECCION LAB. PLANTA PRIMERA	ALUMBRADO LIQUIDOS	CA. ALUMBRADO PES. SOLARES DRIVER CYC PESADAS	CUADRO SEDE SOCIAL P.1* GRUPO	EMERGENCIA NUEVO ZONA SEMISOLIDOS	C. PLANTA TECNICA (AA)	C. LIQUIDOS	C. SEMISOLIDOS CAPSULA	C. EDIFICIO SOCIAL (SA)	CAMARAS CLIMATICAS	C. ALUMBRADO SEMISOL. Y CAP.	C. ALUMBRADO ACONDICIONAMIENTO	C. ALUMBRADO PLANTA TECNICA	C. ALUMBRADO EDIFICIO SOCIAL	C. ALUMBRADO EDIFICIO SERVICIOS	TRATAMIENTO AGUA	RESERVA
POTENCIA (KW)	3,6	2,3	10	10	77	4	200	40	60	20	20	5	6	3	4	3	6	
INT. (A)	0,50	16	14,43	14,43	112	7,2	360,8	72,2	108	36,1	39,22	9,0	10,8	5,4	7,2	5,4	10,8	
SECCION (mm2)	3X2,5	3X2,5	4x6+T	4x6+T	--	4x6+T	3(1x240)+1(1x120)+T	3,5x50+T	3,5*70+T	4x35+T	3,5x35+T	4x6+T	4x6+T	4x6+T	4x6+T	4x6+T	4x6+T	
LONGITUD (m)	10	10	--	--	--	120	155	88	91	200	121	87	113	145	165	9	88	
						1,14	1,69	1,04	1,12	1,53	1,02	1,06	1,51	1,06	1,48	0,30	1,23	

DOCUMENTO:		PROPIEDAD:	
ESQUEMAS UNIFILARES DE FUERZA EN B.T. EN LABORATORIO FARMACEUTICO DE BAYER			
PLANO:			NUMERO:
C. DE DISTRIBUCION DE EMERGENCIA ESQUEMA UNIFILAR			18
ESCALA: S/E	FECHA: FEBRERO - 2019		

