REPORT

SMART REFRIGERATION IN THE BEVERAGE INDUSTRY

The primary consumers of refrigeration needs encompass the food industry, logistics, and retail sectors, collectively representing a global market volume of €11 trillion. These sectors are currently undergoing a significant digital transformation, wherein their requirements extend beyond mere cooling to encompass the imperative of maximizing energy efficiency and environmental sustainability throughout the refrigeration process.

The most efficient refrigeration solutions in the market are NH_3 and CO_2. Consequently, for companies equipped with such facilities, optimizing mechanical consumption becomes challenging. Therefore, in light of this scenario characterized by mature refrigeration technologies with limited potential for theoretical performance improvement, the only way to continue enhancing efficiency is by defining an energy and operational strategy supported by artificial intelligence. The integration of new technologies into the industry will facilitate enhanced efficiency, sustainability and competitiveness, by reducing costs, ensuring uninterrupted production optimizing resources.

The new refrigeration strategy for Industry 5.0 necessitates the implementation of a real-time data measurement and analysis system. This system enables cost optimization through continuous improvement actions facilitated by the development of predictive and optimization systems, utilizing the execution of self-executing intelligent actions. This shift allows for departure from the traditional refrigeration model, characterized by a lack of data and 100% field maintenance, towards a refrigeration model where 70% of actions are self-executing, with efficient energy management.

Furthermore, other issues such as:

- Failures resulting from malfunctions in the refrigeration system leading to merchandise losses and/or production downtimes, as well as high energy consumption.

- Operational and design imbalances in the refrigeration installation hinder the improvement of its performance (COP).
- Difficulty integrating various devices or machines with different communication protocols and from multiple manufacturers.

Differentiation and competitiveness thus lie in data management and refrigeration system control, necessitating an adaptive strategy in consumption, processes, temperatures, etc. to minimize energy consumption and detect faults before they occur, ensuring cold chain integrity and food safety.

Industry 5.0 entails evolving towards energy efficiency, with consumption tailored to the contracted power and the operational and process needs of each industrial activity. It involves investing in maintenance with 70% of self-executing predictive actions.

100% On-site Performance
(Preventive and Corrective)

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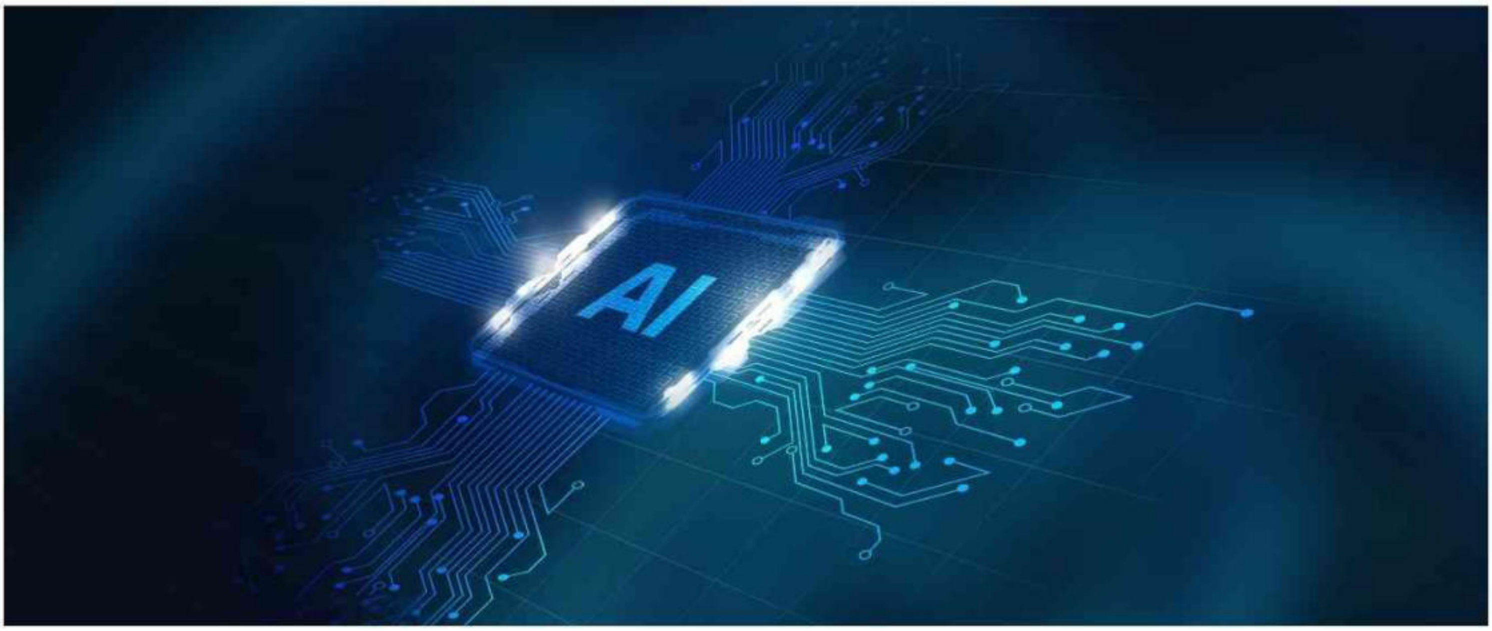
70% Online Preventive and Predictive Maintenance
30% On-site Performance



With technology, we can overcome these challenges and achieve food preservation at the lowest possible cost as a pathway to decarbonization.

These are some of the technologies that enable the integration of intelligence into refrigeration systems:

- IoT (Internet of Things): Connecting and gathering data from various sensors and devices in real-time allows continuous monitoring of equipment and facilitates intercommunication between them.
- AI (Artificial Intelligence) and Automation: Algorithms for facility maintenance and energy optimization can learn from experience automatically. They identify patterns, make predictions, and execute actions based on the results obtained.
- Digital Twin: to compare ideal vs. actual facilities and optimize them accordingly.
- Data Analysis: Advanced techniques for extracting insights, trends, and anomalies from large datasets.
- Cloud Computing: To store and process large volumes of data efficiently. Enables scalability, flexibility, and accessibility for users in different locations.
- Visualization Tools: Sophisticated visualization tools and dashboards to present data and insights intuitively and actionable.

Industrial refrigeration in the beverage sector

The cold chain in the beverage industry encompasses processes from capture, processing, and refrigeration to subsequent storage, distribution, and delivery to the consumer with the highest standards of freshness and quality.

Within beverage plants, the cold chain process employs typical components of a refrigeration system: evaporator, compressor, and expansion device. In this context, the type of evaporator plays a crucial role, as this cooling procedure requires a specialized design as part of the beverage processing system, specifically for mixing and carbonation in the case of carbonated soft drinks, for example.

Refrigeration in the soda, soft drink, and beer industry is akin to water for a living organism, an indispensable factor for its development. Without refrigeration, the product fails to achieve the appropriate characteristics.

In the case of carbonated beverages, refrigeration serves to facilitate the carbonation process, often employing flooded systems, thus playing an essential role in their proper commercialization.

In the brewery sector, the cold chain preserves the taste and characteristic yellow color of beer; without it, there is no flavor, quality, or color.

The use of refrigeration represents a significant step in streamlining the olive oil production process.

The enormous mass of olives harvested annually for oil production in Spain cannot be processed immediately by the industry.

As a result, olives need to be stored and preserved at 5°C to prevent spoilage. This is achieved within the chamber, in the pre-cooling tunnel, which allows for rapid reduction of the fruit's temperature.

Natural Refrigerants

Regarding the refrigerants used in beverage plants, any type can be utilized except for combustible gases such as methane, propane, and others.

Currently, the most widely implemented refrigerant is ammonia (NH_3) for direct cooling, as it possesses excellent thermodynamic properties that make it especially suitable for use in large-scale installations, due to its higher heat capacity.

Refrigeration in industrial beverage processes is a fundamental, essential, and indispensable element for this industry, without which the product cannot exist. Processes must be efficient, reliable, and precise. Therefore, a beverage refrigeration plant, regardless of its type, must be structured to provide high efficiency, durability, reliability, and ease of operation, which are achieved through the implementation of suitable cooling systems.

Monitoring and assets management

Measurement is the first step. It is necessary to be able to read, visualize, and graph interactively (in real-time and historical) all variables and alarms of the different existing assets: machine rooms, cold rooms, and the services to which they supply cold, sales rooms with various refrigerated furniture, as well as any other electrical or process variables from other facilites.

This monitoring should allow the integration of different communication protocols (MBUS, IEC, XML, IPC...) of all assets (with different control systems: SCADA, BMS, PLC...) regardless of their brand, thus monitoring everything from a single location.

With access from a control panel to all your centers and facilities, various real-time reading panels of all variables related to existing assets and corresponding alarms can be created within each center.

We should also be able to access the historical data, and in an agile and interactive way, graph the signals and alarms we want over a specified period of dates.

Finally, assets must be classified energetically, allowing for differentiation between the various types of actions that can be taken on them and facilitating technical-energy decisions regarding their operation.

INTEGRATION OF OTHER ENERGIES

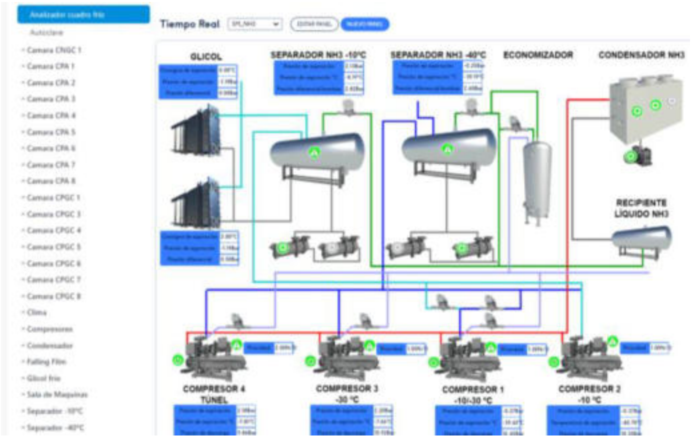
It is crucial that throughout this refrigeration process, renewable energies available can be managed; in other words, utilizing them for refrigeration system management, leading to greater energy and economic savings.

Therefore, centrally integrating other energy and production process variables such as solar, photovoltaic, water, compressed air, cogeneration, fire prevention, electrical energy, photovoltaic, gas/vapor, ventilation, etc., would transform it into a business management system with even greater potential.

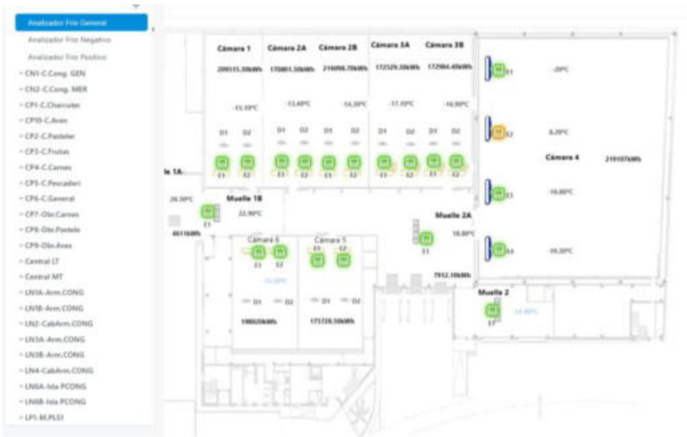
This integration also enables action on air conditioning, lighting, etc., facilitating a much more comprehensive and complete management approach.

Monitorización y gestión de activos

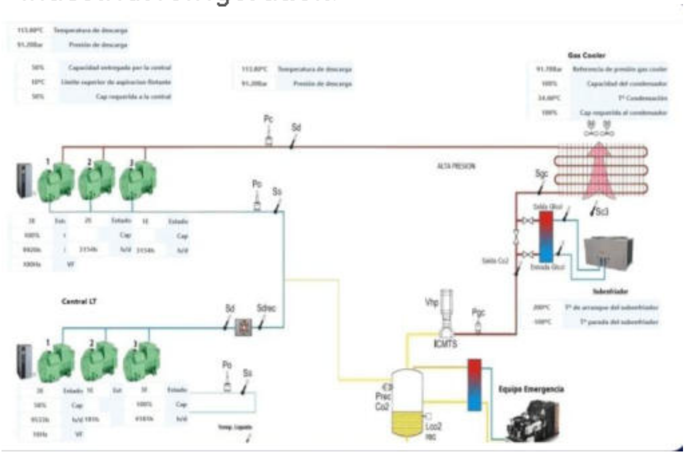
Interactive monitoring panel. Refrigeration plant. Industrial refrigeration.



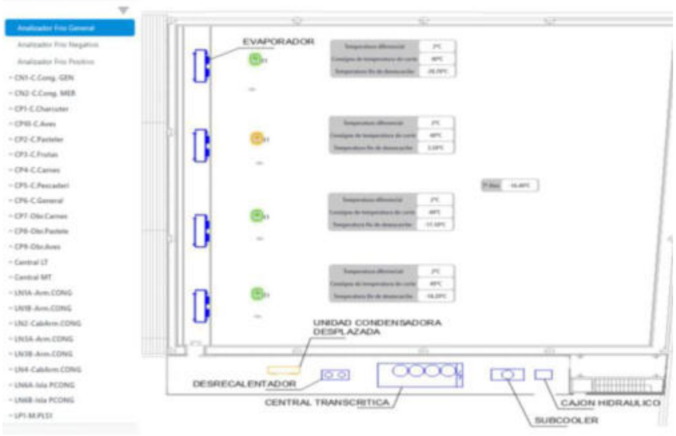
Interactive monitoring panel. Cold rooms. Industrial refrigeration.



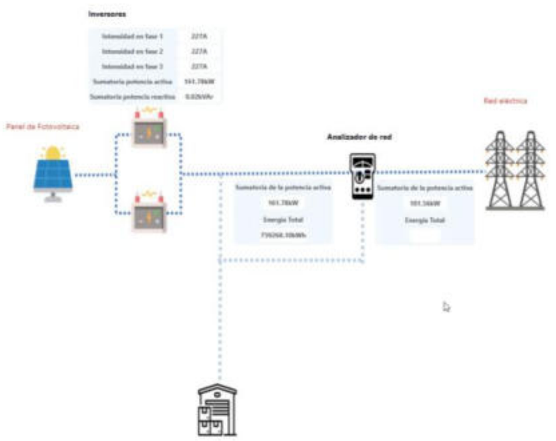
Interactive monitoring panel. Refrigeration plant. Industrial refrigeration.



Interactive monitoring panel. Cold room. Industrial refrigeration.



Interactive monitoring panel. Photovoltaics.



Interactive monitoring panel. Commercial air conditioning.

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Optimization and energy management

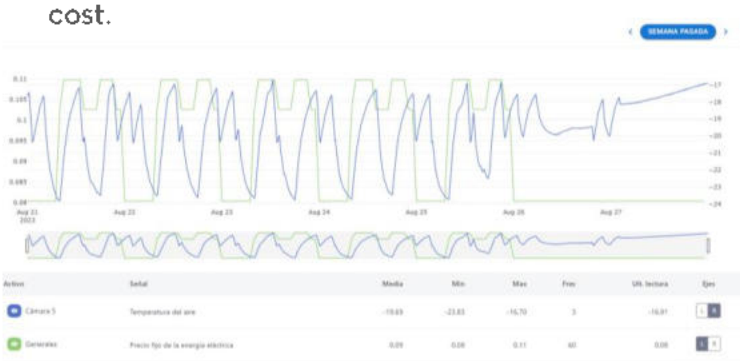
OPTIMIZATION

The optimization process enables intelligent management of both energy demand and production.

The goal is to set adaptive temperatures based on real-time needs in a particular refrigeration system, taking into account electrical producers, contracted tariffs, and customer processes.

The optimizer calculates the temperature evolution in the future, adjusting setpoints to minimize costs.

In the bottom graph, we see an example of automatic actions taken on the operation of a cold room to adapt to the tariff periods with lower cost.

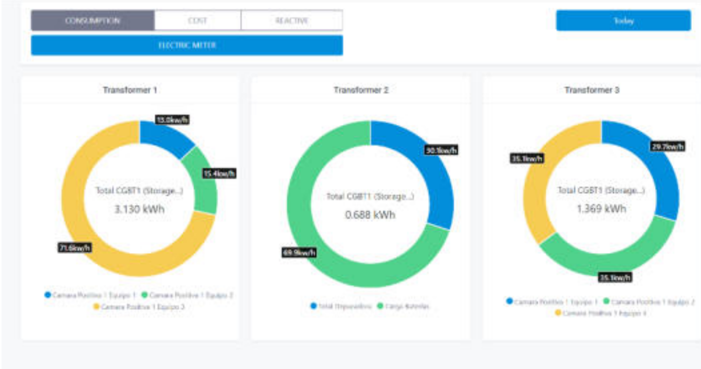


Additionally, it should be able to manage equipment start-ups and shutdowns based on predefined priorities to avoid excess consumption.

In the bottom graph, we see an example of the evolution in the linearity of compressor operation.

ENERGY

Regarding energy, it's very interesting to be able to visualize a consumption structure where we can see the energy consumed in different areas of the facilities, and within these, consumption per time periods.



Similarly, it is ideal to have a visualization of invoices with the customized consumption structure defined and a forecast of expenses, allowing us to anticipate the electricity company's bill.

Preventive and predictive maintenance

To successfully implement a preventive and predictive maintenance strategy, it is crucial to have a system that monitors the refrigeration installation to ensure maximum efficiency, predicting deterioration before it occurs and executing automatic actions to correct detected pre-faults.

Sensors collect information on physical variables and generate data to create a digital record stored and analyzed in the cloud. This data is processed to obtain normalized data (big data and deep learning).

Predictive models can forecast the temperatures of products and structures stored inside cold rooms. By utilizing mathematical equations that relate multiple variables, it is possible to optimize and extract optimal values at each moment to reduce operation costs of the installation and consequently ensure the optimal condition of the product.

Statistical models, based on neural networks, can make predictions to verify the proper functioning of the installation and, if necessary, proceed with the correction of any detected faults.

In case of detecting potential deterioration or malfunction, intelligent alarm management would be initiated, generating a completely transparent record that allows action to address the reasons for the alarm. If the absolute difference between theoretical and actual values of signals exceeds a threshold, that difference and the date it occurred will be saved.

If, in subsequent analyses, this difference increases over time, it indicates equipment deterioration or malfunction.

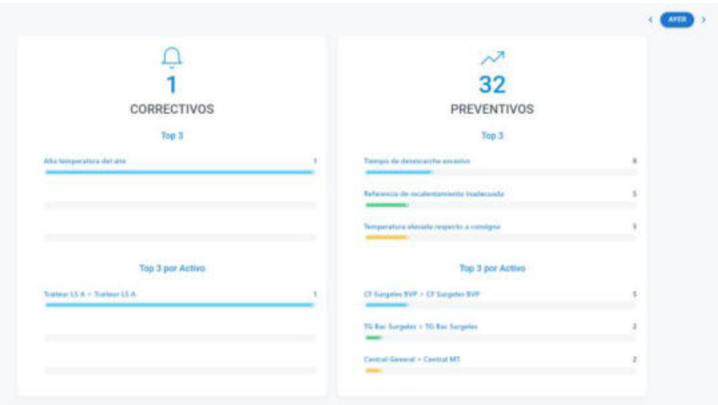
This analysis would be carried out alongside operational rules to detect the origin of the fault and resolve it.

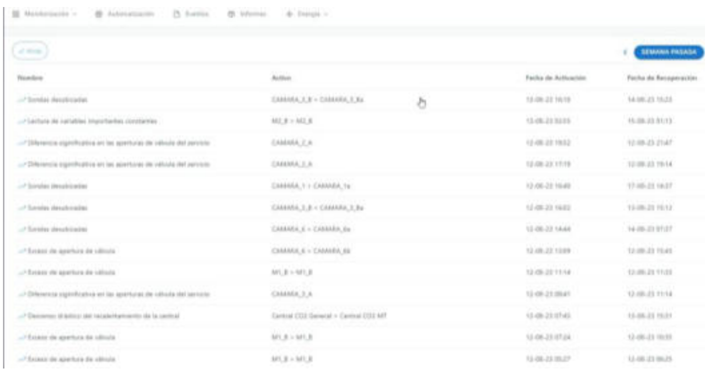
This requires software containing all corrective and preventive alarms that continuously analyze the installation, essential for its optimal operation and maintenance.

Preventive alarms detect patterns or early signs of malfunction. Events with different priorities are thus generated, anticipating faults, and indicating when they occur, whether they have been resolved or not.

For preventive events, a brief explanation of what is happening is provided, and personalized notifications can be activated or deactivated to alert the corresponding user.

These events can be automated, meaning a rule with a condition (value, date, day, time) can be defined for each one, such that if the condition is met, a specific action is executed.

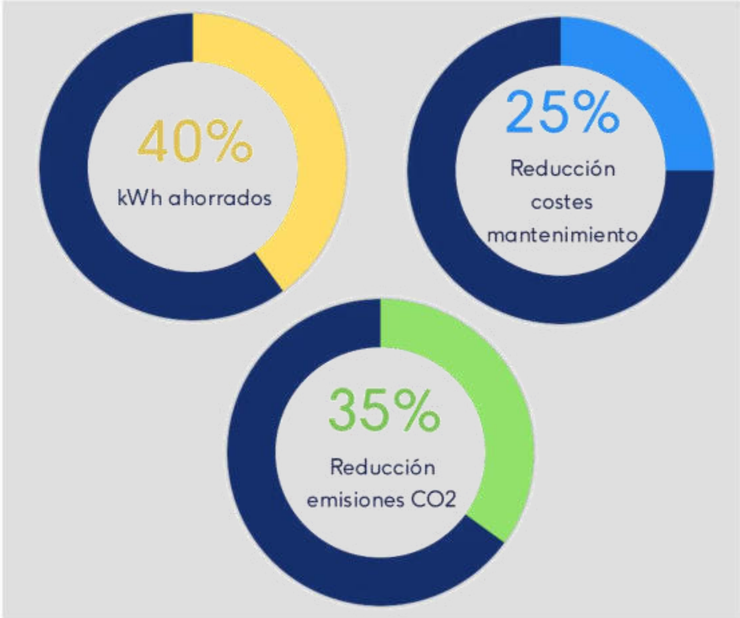




Benefits

All the aforementioned actions in this report imply that, with the actions that can be taken, the following outcomes can be achieved:

- Energy savings: Between 20 and 40%.
- Reduction of maintenance costs: > 25%.
- Sustainability. Reduction of carbon footprint. Reduction of between 20 and 35% of CO_2 emissions.
- Significant improvement in the personal life of maintenance personnel, as it avoids having to attend at night and during weekends by 70%.
- Products in perfect preservation conditions. Food safety. No merchandise losses.



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And now, what's next?

Thanks to technology, we can perform continuous analysis of refrigeration installations and generate automatic actions to optimize their operation, preempting failure before it occurs and ensuring optimal performance of the refrigeration facilities. This offers advantages in efficiency, operational reliability, and product control and traceability.

Undoubtedly, the food industry is one of the major beneficiaries, with various financing options and subsidies aimed at implementing energy management systems in the industry to reduce final energy consumption and CO_2 emissions from industrial facilities.

The key question industry must ask itself is: do I anticipate now or adapt later? What is the value of knowing that a critical installation in the production process will not only avoid failure at the most inconvenient times but will also predict its deterioration and execute actions to optimize its operation and energy savings?

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