CONAD ADRIATICO

CAREL retail sistema

the one solution

ITA

retail sistema come soluzione per l'energy saving

Studio di un impianto reale dotato di tecnologia meccanica ed elettronica

ENG

retail sistema as an energy saving solution

Case study of a working installation using both mechanical and electronic technology

CASE STUDY

Integrated Control Solutions & Energy Savings

The project

Within the context of continuous innovation and energy awareness, an installation has been developed using outstanding technological solutions, so as to demonstrate the advantages in terms of energy saving of using the latest technology systems and cutting-edge control solutions.

Numerous studies on the running costs of supermarkets show that over 50% is accounted for by the energy consumption of the refrigeration system, first of all, and secondly by room air-conditioning. The focus in terms of energy saving is thus on these two areas.

The availability and environmental awareness of CONAD ADRIATICO and its willingness to invest in research into innovative solutions allowed a valuable partnership to be established between:
- The CONAD ADRIATICO technical department, which coordinated the operations in the field;
- CAREL S.p.A. (integrated system: controllers and components for complete store management, including room air-conditioning and energy monitoring).

Description of the systems and further details

Introduction

The supermarket examined in this document, located in Sulmona (AQ), when compared to other similarly sized supermarkets (~2000 m^2), stands out for the fact that it is focused on fresh products. Consequently, it consumes more kWh in refrigeration per square metre.

The installation is more complex than others of the same size, due to:
- the type of climate: Sulmona sees considerable temperature differences both throughout the day and between the seasons, ranging from down to -5°C in winter, to 38 °C in summer;
- the store is located in a residential area, thus the noise from compressors and fans must be kept to a minimum;
- installation difficulties relating to the location of systems and condensers in the basement: this required the use of centrifugal fans on the condensers.

Systems

The cooling capacities of the two compressor racks was defined based on the number of medium and low temperature units required by CONAD. Following this the compressors were chosen, considering the maximum outside temperature, which affects the compressor rack condensing temperature.
The cooling efficiency of a compressor is a function of the evaporation and condensing temperature. For the same evaporation temperature, a decrease in condensing temperature represents an increase in the efficiency of the system, that is, an increase in the cooling capacity delivered by the compressor, and at the same time decreases compressor power input. The most critical operating condition is thus a higher condensing temperature, which in turn is a function of the air temperature, as air is the fluid that cools the condenser.
The installation consists of a compressor rack operating on R404a, which delivers refrigerant to the condenser. The condensed fluid then flows to the refrigeration units, installed with the expansion valves required to ensure the correct operating temperature.
To compare the Carel solution against the more common mechanical solution, the display cases have been fitted with two expansion valves in parallel: the classic mechanical expansion valve (TEV) and the Carel electronic valve (E2V).

The medium temperature system consists of:
- 23 refrigeration units, cooling capacity required 80kW
- compressor rack with three compressors
- one condenser with two centrifugal fans managed by inverter.

The low temperature system consists of:
- 10 refrigeration units, for a total of 16 kW
- compressor rack with four compressors
- one condenser with one centrifugal fan, managed by inverter
- hot gas defrost of the units.

On the air-conditioning installation, a CAREL solution has been adopted to optimise energy consumption of the condensing boiler - heat pump system based on the outside temperature. This exploits the energy efficiency of the heat pump at temperatures above 7°C.

The use of the integrated CAREL retail sistema solution ensures maximum benefits from the energy saving functions available on the various controllers in the refrigeration system. System integration and the objective of reaching the best operating conditions at all times mean optimised performance, guaranteeing an environmentally-friendly solution.

System management and control

Compressor racks

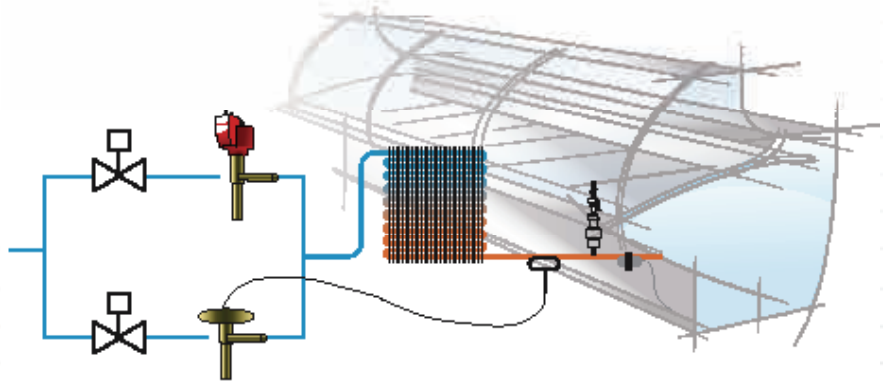
CAREL "rack controller" on pCO3 board with inverters

Rack controller

VFD

Refrigeration units:

CAREL "MPXPRO" with E^{2}V and TEV valves.
The installation has been fitted with dual technology to allow analysis that is as accurate and realistic as possible: the display cases and cold rooms have been fitted with both CAREL E2V electronic valves and traditional thermostatic valves.



Room air-conditioning

Solution that optimises the boiler/heat pump requests and heat energy metering using customised CAREL software

Supervision, optimisation and consumption metering: CAREL PlantVisorPRO.

Further information on energy saving

System integration

The meticulous design and development of the installation has allowed the system to be optimised by integrating the CAREL Retail sistema solution.

The use of the integrated "CAREL retail sistema" solution for refrigeration systems ensures maximum benefits from the energy saving functions available on the various controllers in the system.

The PlantVisorPRO supervisory system monitors all the controllers in the field, both refrigeration and air-conditioning / heating (including third party devices), managing the exchange of information so as to create different types of operating logic, with the objective of achieving the maximum energy saving possible.
The operation of each individual refrigeration unit can be monitored at all times and managed from the supervisor. The HACCP data can also be downloaded and printed.

All this means the CAREL retail sistema can achieve maximum energy saving and ensure the flexibility required for an environmentally-friendly development.

Some details on the solutions adopted:

Floating compressor rack operating pressure
(Rack controller + PlantVisorPRO)

The power input of a compressor is proportional to the difference between the suction and discharge pressure. Consequently, if this pressure difference can be controlled, energy consumption can be limited, where possible.

Floating condensing pressure
Based on the difference between outside temperature and condenser temperature, a dynamic condenser control set point can be used in real time.
This system exploits low temperatures in winter and thermal fluctuations between day and night, without wasting energy with full operation of the condenser fans.

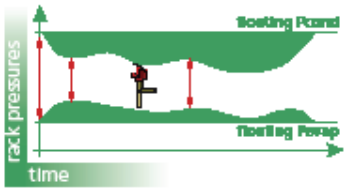
Lowering the condenser control set point brings a direct and significant reduction in compressor power input.
In addition, using this algorithm ensures less refrigeration system compressor wear, as the average annual discharge temperature is lower.
Consequently, there is an increase in performance and less deterioration of the oil and the mechanisms in general.
This function can only be used if the installation is fitted with electronic valves, as they have a wider range than thermostatic valves, that is, they also work correctly with lower expansion than the normal operation envisaged in the design conditions.

Key:
1. outside temperature;
2. rack controllers;
3. speed optimisation;
4. efficiency optimisation;
5. electronic expansion valves.

Floating suction pressure

The suction pressure set point can, with sound system operation, also be dynamic.
In fact, if all the units are working correctly, the suction pressure set point can be increased.
This is done using the supervisory system, which acquires the information from the various controllers and consequently optimises operation.
These operations are performed automatically in the background by the installation supervisor.

As a result of these two optimisations, the installation always works with the minimum pressure difference allowed by the climatic conditions and the thermal load.
Using the E2V expansion valve maximises the results, allowing the smallest pressure differences possible.
The supervisory system can continuously monitor the instant power consumption of the two compressor racks, thanks to the installation of two energy analysers, one for the medium temperature rack and the other for the low temperature rack



Electronic valves (E^2V)

Floating condensing and evaporation pressure control are optimum only when electronic expansion valves area used, as have a wider range than common thermostatic valves: this significantly increases possible savings (electronic expansion valves 25% annually on average, without electronic expansion valves 8% annually on average), see the article in GDOWEEK June 06, experience with TESCO UK.
Mechanical expansion valves are sized for the most extreme operating conditions, that is, in summer. In addition, they require calibration to optimise operation, a procedure performed during commissioning by tightening or loosening a screw. This procedure is quite complex, and is not performed in actual operating conditions, but rather when the refrigeration units are discharged.

The use of E2V valves also brings increased performance of the evaporators in the refrigeration units and greater internal temperature stability: the result is better storage of foodstuffs.

Anti-sweat heater optimisation by dewpoint (MPXPRO)

As regards the refrigeration units, a new energy saving function has recently been introduced, involving modulation of the anti-sweat heaters. This function can be activated on all cabinets where condensate or mist may form on the glass or the frames.
Normally these heaters operate 24 hours a day, even the climatic conditions would allow modulation or even deactivation.
Modulation is made possible by the supervisory system, which shares the ambient temperature and humidity data so that the MPXPRO controller can calculate the dewpoint and consequently adjust the operation of the heaters.

Inverter (VFD)

Inverters, by modulating the frequency of the power supplied to the electric motors on the fans and compressors, reduce peaks in power consumption, and in addition ensure more stable condensing and suction pressure, holding the effective value around the set point without continuous stops and starts.Having stable condensing and suction pressure means greater evaporator efficiency and increased stability in the management of the electronic valves (even if this is not essential). These comments apply above all to systems where there are considerable temperature differences. In fact, systems are always sized for the worst conditions, that is, in summer. There is thus the risk that the compressor rack is oversized for the winter (above all when electronic valves are used), with the motors continuously starting and stopping, meaning higher power input and a probable reduction in the life of the motors. In this installation, inverters are used to manage the condenser fans. As mentioned previously, the condensers have centrifugal fans, being located in the basement. To decrease motor power and consequently noise, two inverters have been used, one for the condenser on the medium temperature compressor rack, the other for the low temperature rack.

Hot gas defrost

Another source of energy saving is represented by the defrosts on the low temperature display cases; indeed, rather than defrosting using electric heaters as is normally the case, the hot gas from the compressor discharge is used. This gas is forced into a third line, which carries it to the evaporator being defrosted. The evaporator in this case acts as a condenser. The condensed fluid at the evaporator outlet the returns to the liquid line that supplies the other evaporators.
The use of hot gas allows faster defrosts and better cleaning of the evaporator coil, as the gas flow through all the branches of the evaporator. Optimised organisation and coordination of the defrost calls is fundamental when using this type of defrost.

Optimisation of boiler operation as heat pump support

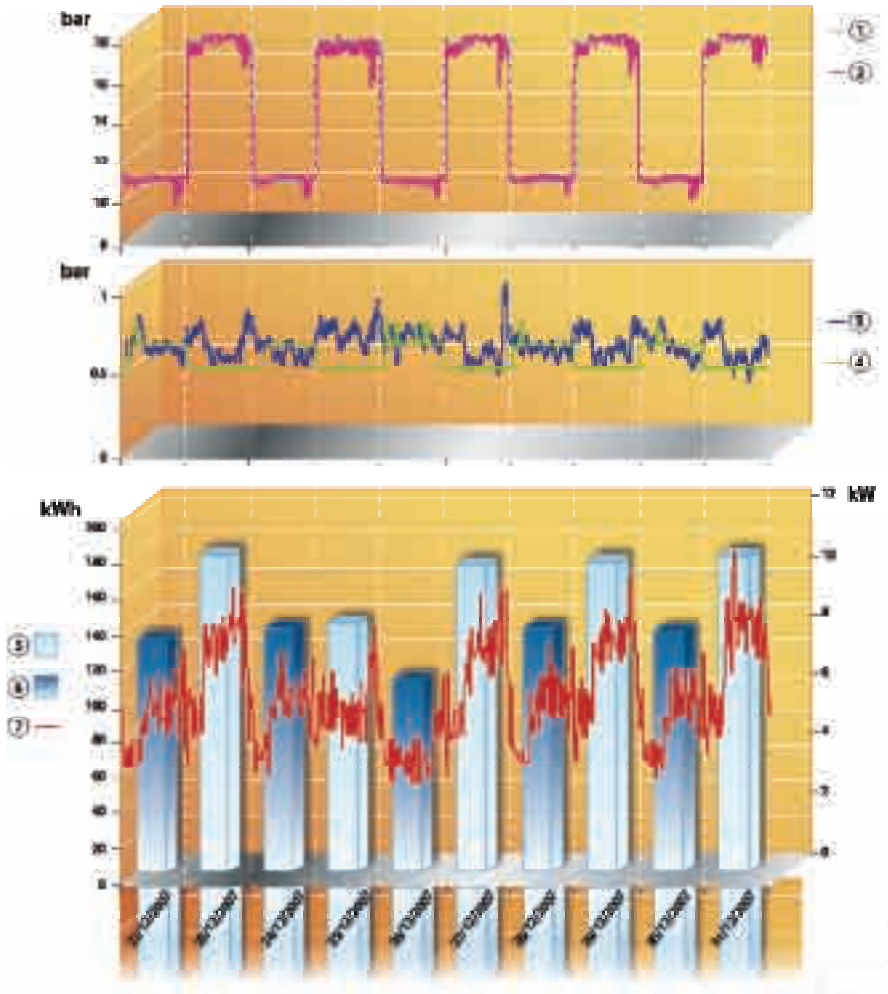
The supermarket has also been installed with a CAREL solution that optimises the heating system. Based on the outside temperature, in fact, the energy from the condensing boiler or an air-water heat pump fitted with inverter-driven centrifugal fans can be used. This solution fully exploits the good heating efficiency of heat pumps at temperatures above 7°C.
A board is available for the PlantVisorPRO supervisory system to manage this system.
in addition, the supervisor also includes the possibility to monitor heating energy consumption.

This document does not examine the results of the latter system, as an additional winter season is required in order to evaluate effective energy savings.

Results

The use of the supervisor has allowed the operating logic to be changed every 24 hours, switching from standard mechanical control (TEV thermostatic valves) to the more recent yet consolidated electronic control (E2V valves). This has allowed comparison between days with near-identical climatic conditions and thermal load.
In the period from November 2007 to June 2008, a series of interesting energy consumption data was acquired from the supervisor as regards optimisation of supermarket operation.
The figures below show graphs on the changeover from mechanical to electronic operation and the power input of the low temperature compressor rack.

Operating pressure and power input



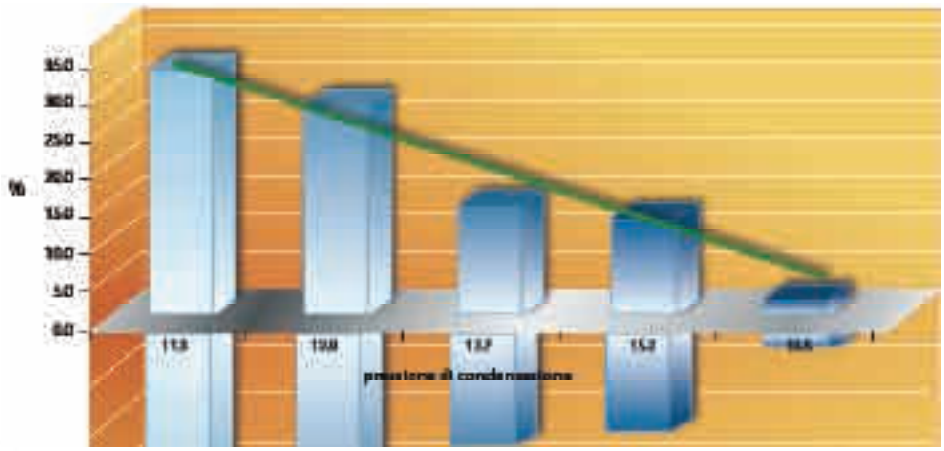
Key:

1. condensing pressure set point;	4. suction pressure	7. power;
2. condensing pressure;	5. daily consumption in mechanical mode (MEC);	
3. suction pressure set point;	6. daily consumption in electronic mode (EEV);	

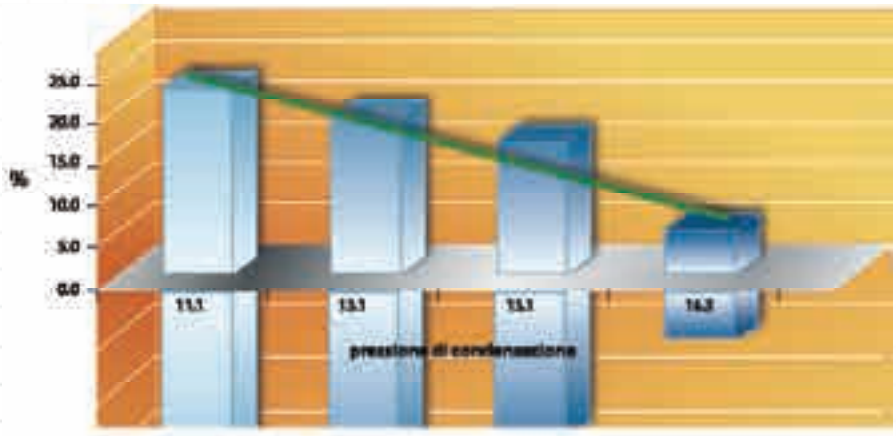
The previous graph shows one of the busiest periods in a supermarket (22, 23 and 24 December) as well as two days on which the store was closed (25 and 26 December).
As can be seen, the average instant power input during the day and consequently the daily power consumption are lower in electronic operating mode, both comparing days the store is open (especially prior to and following holidays, peak business) and on days the supermarket is closed.
The data acquired over these months, together with the climate profile in Sulmona, can be used to estimate average daily and monthly refrigerating power consumption for the entire year.

Estimated average savings according to the condensing pressure

MT saving: % gain



LT saving: % gain

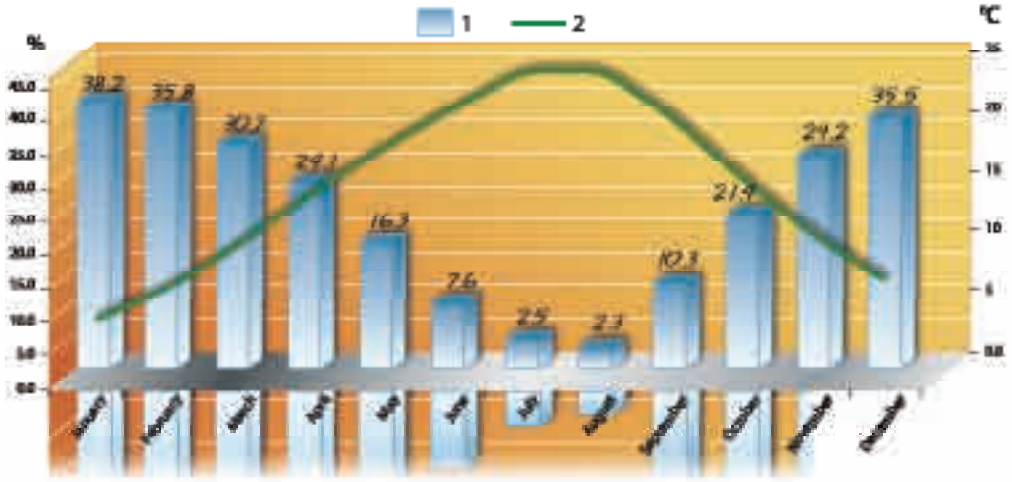


The final results speak clearly, savings are estimated to be around 20% for both the medium and low temperature system.

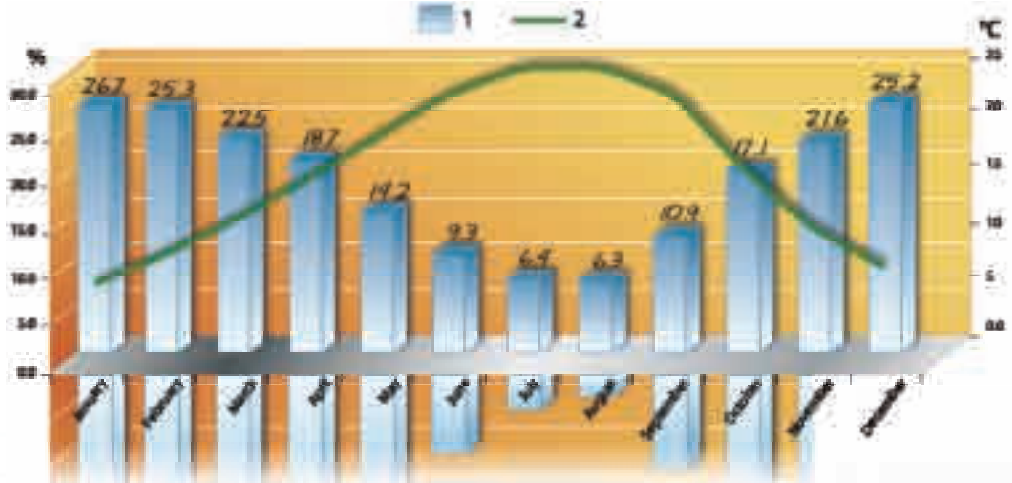
As can be imagined, the advantages of the electronic solution are reduced considerably in summer. The graph shows the climate profile in Sulmona, with the average monthly temperature and the percentage gains when using the electronic solution compared to the mechanical system.

Estimated average monthly savings according to the outside temperature

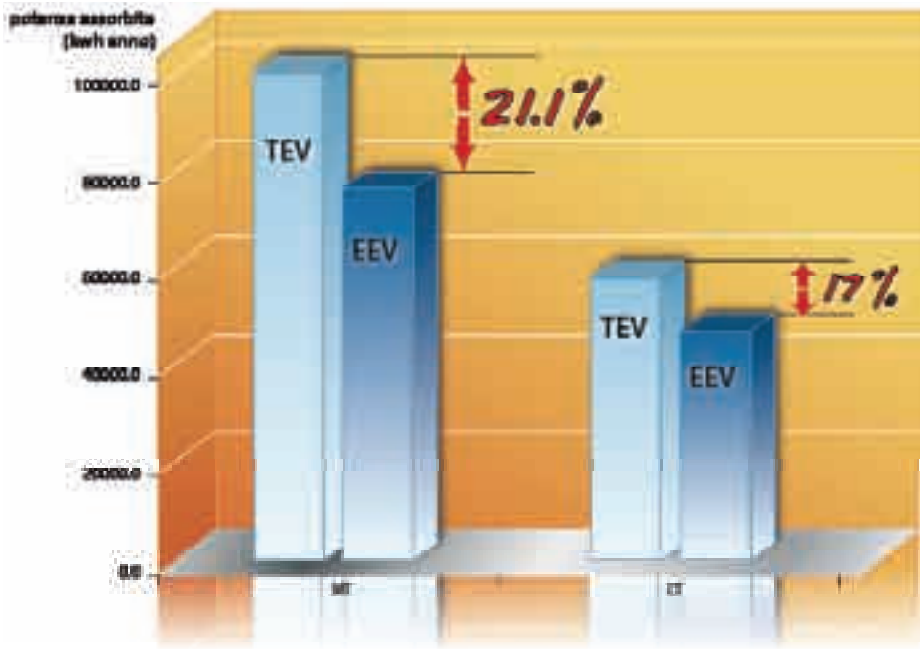
MT: % Power saved in EEV mode



LT: % Power saved in EEV mode



Annual estimated energy saving for the CONAD ADRIATICO store examined in this study.



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