Application note

BEMS & IAQ

Building Energy Management Systems & Indoor Air Quality

Buildings today are required to function with the highest levels of efficiency, constantly maintaining the correct balance between operational needs, environmental conditions - outside and inside - and energy consumption. As part of this process, monitoring and control of all the fundamental parameters for indoor air quality is essential.
Being able to analyse systems that differ in terms of conditions and technologies, highlight deviations from optimal performance and make the information accessible to all types of users are the needs that we have been able to respond to, exploiting our decades of know-how in control systems and IoT systems, applying normalisation logic and modelling of expected behaviour, so that experts can focus on truly critical cases and optimise efficiency at all levels.

Where
Complex tertiary sector buildings and/or multi-site commercial/tertiary facilities

What
Monitoring and management of energy-intensive building systems to ensure optimal environmental conditions.

Why
Obtain and maintain the highest energy performance of buildings, guaranteeing the comfort, health and consequently productivity of occupants

Objectives of the initiative

- Achieve significant cost savings by reducing energy consumption
- Adapt and update buildings housing bank branches with relation to specific regulations, such as Italian Legislative Decree 102 of 4 July 2014, implementing Directive 2012/27/EU on energy efficiency, which obliges large companies to have quarterly energy audits carried out by accredited bodies.

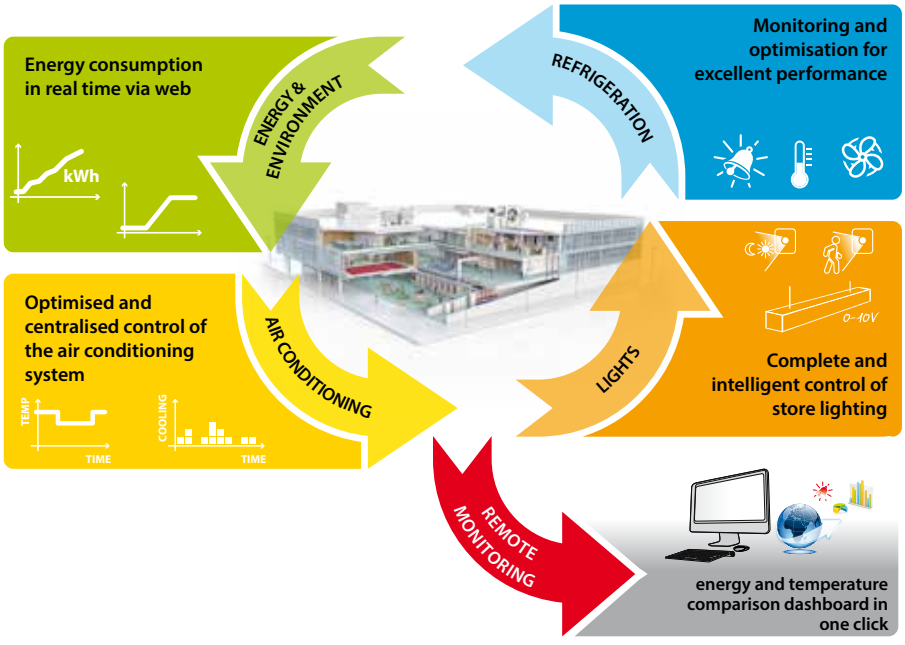
Requirement

To install a BEMS in buildings housing bank branches, with complete remote management of technological systems and monitoring of the main environmental and energy parameters.

The CAREL BEMS solution

The CAREL BUILDING ENERGY MONITORING SYSTEM (BEMS) is a solution designed to ensuring indoor comfort in terms of environmental conditions and lighting, optimising and reducing energy requirements. It is ideal for:

- **Energy efficiency:** by integrating different systems, advanced control logic can be adopted to align production and supply of energy in real time, with the actual demand of the building. The use of schedulers and occupancy helps eliminate existing energy waste. Aggregation of energy data from all connected devices and all systems in just one single point offers the opportunity to easily carry out analysis and produce graphs, benchmarks, dashboards, etc., as well as to evaluate the savings achieved following the implementation of the BEMS.
- **Indoor comfort:** constant monitoring of temperature-humidity and air quality means the project comfort KPIs can be guaranteed at all times.
- **Normalisation, analysis and processing of collected data:** creation of energy performance indicators and comparison against historical data.
- **Optimised maintenance:** remote monitoring of all connected devices and centralised alarm management with assigned priority and activation rules makes it possible to optimise the use of equipment and reduce maintenance costs, preventing failures or malfunctions and planning service.
- **Simple implementation and management:** the ready-to-use system is a compact, flexible and modular standard solution that can adapt to different types of systems. With extensive Ethernet connectivity and the availability of the most popular communication protocols, it can be integrated into all systems, both new designs and retrofits.



The logic of the CAREL BEMS system is based on the following steps:

- **Know:** the first step towards efficiency. The indoor and outdoor conditions and energy consumption are acquired through a series of dedicated field devices that transmit information to the system, where this is stored.
- **Manage:** the controller processes the information acquired in the field, processes it using advanced internal algorithms based on the user's requirements, and controls the technological systems to achieve the set objectives.
- **Monitor:** the system provides the tools needed to collect and log operating information from all controllers in the branches, providing a graphic interface for real-time control and monitoring of systems with advanced tools for energy analysis.
- **Optimise:** centralising information and creating a direct benchmark between the different points in the network are the main operations for maximising energy savings. Performance analysis allows the most successful cases and those with negative deviations from the objectives to be identified. Identification of deviations leads to increasingly detailed analysis, down to an individual unit level, to understand and resolve the root causes of below-par performance. Any malfunctions in the network are also promptly notified, with the possibility of remote troubleshooting, without needing to physically go on site.

Technical details of the application

Provide a turnkey solution

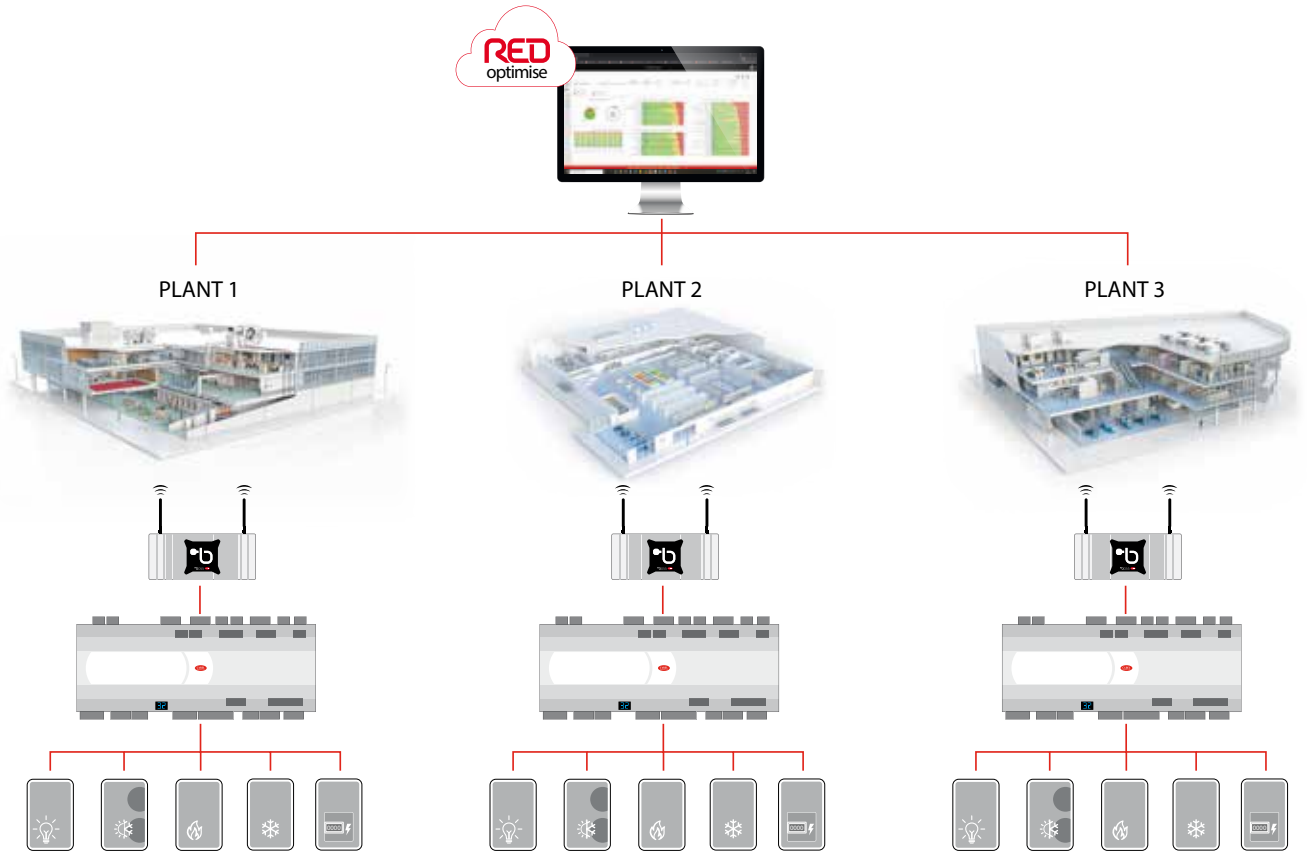
- Electrical panels including c.pCO programmable controllers, supervisors with Modbus RTU or TCP/IP and BACnet TCP/IP communication, I/O expansion cards, communication gateways with third-party devices, electricity meters;
- Temperature and humidity probes and sensors;
- Lighting control;
- Local supervision with Boss field edge;
- Software for remote centralised monitoring of all branches.

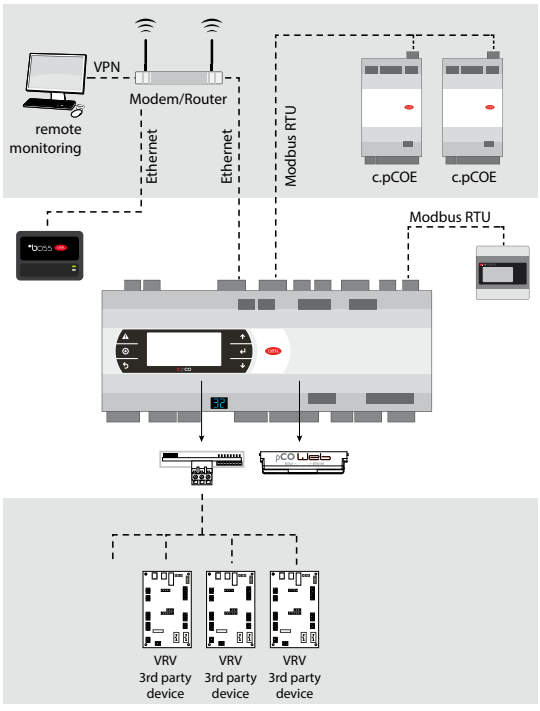
Main features

- remote activation/deactivation of technological systems;
- monitoring of energy consumption in each branch;
- normalisation, analysis and processing of collected data;
- creation of energy performance indicators and comparison against historical data;
- evaluation of savings achieved following implementation of the BEMS.

BEMS system architecture

The new control and supervision system follows a pyramid logic, starting from the controllers for managing individual technological system functions and moving up to the centralised remote monitoring system for the entire network.





The heart of the system in each branch is an electrical panel that houses a programmable controller, energy meters and optional gateways for integration of third-party devices using the most common building automation communication protocols.

It is a unique and scalable application that guarantees operating flexibility, but also the benefits of a uniform and easy-to-use solution.

The system and software are already designed to allow expansion of the control system in the future.

The local supervisor ensures operation of the system and data logging even with remote connection failures.

The controllers are part of the Carel c.pCO family of freely programmable electronic controllers, featuring extensive IP connectivity and the availability of the most common building automation communication protocols.
The c.pCO controller acquires information on indoor and outdoor environmental conditions through the input channels, processes the information using integrated algorithms, and controls the output channels to manage the heating/cooling and lighting systems. Through its serial communication ports, it also manages the operation of the most common VRV/VRF air conditioning systems, and receives information on energy consumption via the serial bus.

The application software has been designed as a suite of interdependent modules, one for each of the controlled functions:

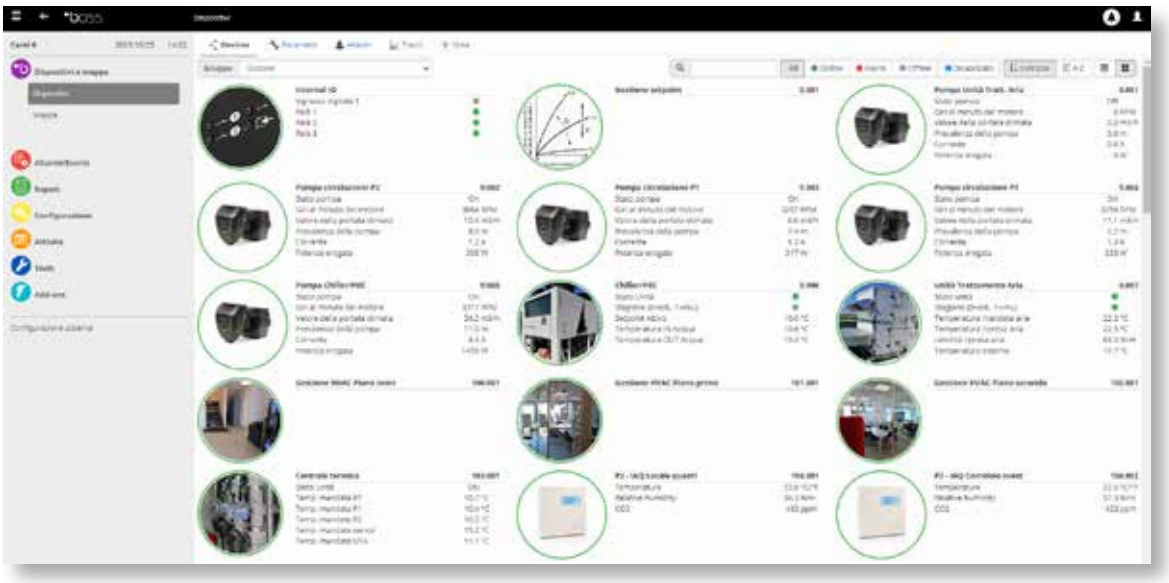
- **Air conditioning:** management of heating, cooling and domestic hot water production systems; integration of air handling units, fan coils and interface with the most common VRV/VRF direct expansion air conditioning units.
- **Lighting:** management of inside and outside lighting systems based on a scheduler, or by twilight sensor, with the possibility of emergency or timed switching on.
- **Energy monitoring:** electricity consumption divided into categories (general, heating/cooling, lighting and general loads) and integration of energy consumption measurements from other utilities (water and gas).

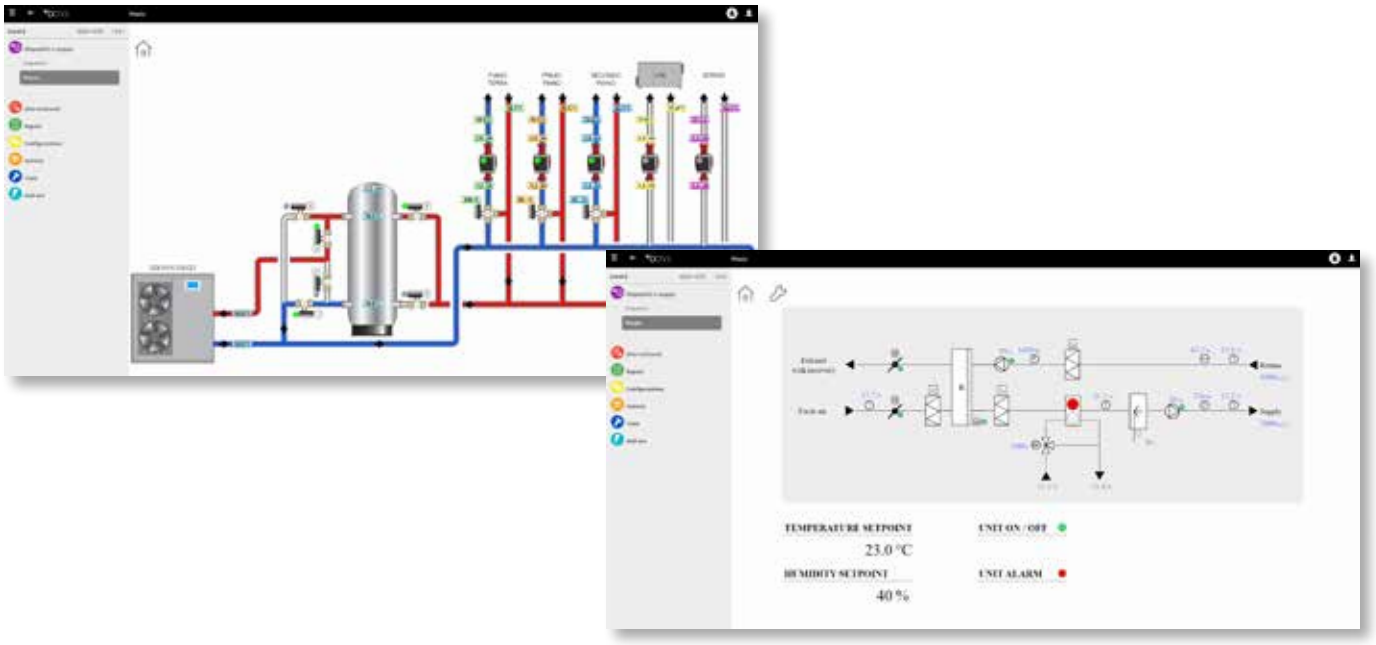
A boss mini local supervisor guarantees remote control of each branch.

Centralised supervision and monitoring system

Each bank branch is connected, via VPN, to a centralised supervisory system. RED is remote supervisory software capable of controlling the BEMS panels in the various bank branches via Ethernet, communicating with the local Boss supervisors using a secure HTTPS protocol.
The enterprise software system used to monitor this system can centralise data from thousands of branch offices. It provides an integrated dashboard suite to ensure the sustainability of each individual building in terms of performance and efficiency, helping customers easily identify where they can take action to optimise the system. Different users with different profiles can access the remote supervisor to view different information. Any malfunctions in the network are also promptly notified, with the possibility of remote troubleshooting, without needing to physically go on site.

Map of heating/cooling devices and systems





Browsable floor plans for controlling room set points and operating times

Monitoring of environmental parameters to maintain comfort and air quality standards

Global analysis dashboard of the entire set of buildings for alarms, energy consumption and comfort performance

Energy benchmark, variable log, variable reports, energy comparison between different sites

Analysis, history and alarm reports

Optimisation

Application of the BEMS solution, in addition to controlling and monitoring technological systems, also allows implementation of sophisticated and intelligent logic to optimise control and maximise energy savings, through in-depth knowledge of environment-system-user interactions. The data acquired in the field is processed using machine learning techniques, so as to be able to interpret extremely complex phenomena and identify the best solution.
Analysis of the parameters controlled by the BEMS system serving the bank branches is aimed at identifying correlations between variables affecting energy consumption, creating a reference baseline that simulates behaviour of the site in order to optimise performance of the building-systems.

The following phases are adopted:

- **Screening:** to analyse all logged, controlled parameters and define the objective variable and output parameter to be controlled;
- **Data analysis:** to define preliminary data processing procedures and create the

reference baseline for clusters of similar branches;
- **Model creation:** analysis of statistical correlations between operating variables, identification of "dominant" factors, modelling of system behaviour and calibration of the mathematical model using machine learning algorithms;
- **Control and optimisation:** development of predictive control algorithms for HVAC systems managed by the BEMS;
- **Savings reports:** the mathematical model created can be used to compare actual energy consumption and precisely quantify the savings obtained.

After the process, a fine tuning phase is applied, where the following are identified:
- Optimised ON/OFF times;
- Activation and management of temperature set point control;
- Freecooling activation and management;
- Optimisation prior to switch on;
- Optimisation prior to switch off.

Conclusions

Analysis of hundreds of "certified" implementations (in different types of buildings and organisations) has demonstrated of a return on investment exceeding initial expectations, further boosted by overcoming the excess caution in defining the environmental conditions suitable for the application scenario.
The architecture, completed by the centralisation system, allows a target benchmark system to be applied for fine tuning system control and further improving the results in terms of energy savings.
The local (boss) and remote/centralised (RED) control and supervisory systems are natively designed to involve the entire facility (both inside and outside of the building) in achieving the set objectives and in the analysis of areas for improvement.

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