About the contribution of BAC and BMS to energy performance of buildings

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The key-role of Building Automation and Control and Technical Building Management is to minimize building energy use and related greenhouse gas emissions required to operate any building tending at the same time to ensure both human comfort and the occupant's satisfaction with room climate conditions. It is obvious that organisation and management of HVAC systems is at least as much important as the installation of energy efficient and well-designed energy related products. Finally, the question raises: how to quantify and visualize this outstanding importance of building management systems to interested parties as designers, investors, building operators, and building owners, respectively? Within the EPBD calculation framework EN 15232 is well known, for years, as European standard describing, classifying and evaluating different BAC functions having an impact on the energy performance of buildings. These system specific control functions realized are dedicated to the physical chain of transformation of the energy, from Generation, to Storage, Distribution and Emission. Controllers are communicating along the chain and across different disciplines (e.g. heating, cooling, ventilation) via a standardized open bus, such as BACnet, KNX or LON. This multidiscipline and complex control (heating, cooling, ventilation, DHW, lighting…) can be used for optimization. For example, INTERLOCK, is a control function that avoids heating and cooling in same time.

Usually the functions implemented in the controllers can be programmed or adjusted by choosing certain parameters. The CONTROL FUNCTIONS present in a BAC system or TBM, are organized in EN 15232 according to the matrix given by Modular Structure of EPB standards. The Table starts with Heating Emission, Distribution, Storage and Generation followed by Domestic Hot Water, Cooling, Ventilation and Lighting. Each function is described in detail, in accordance with the type (level) of the function: from the lower type (NO AUTOMATIC CONTROL Type=0) to most advanced types. For practical reasons, four different BAC efficiency classes (A, B, C, D) of functions are defined both for non-residential and residential buildings. This is the fastest way to specify a BAC or a TBM.

- Class D corresponds to non-energy efficient BAC. Building with such systems shall be retrofitted. New buildings shall not be built with such systems. One is in class D: If the minimum functions to be in class C are not implemented.

- Class C corresponds to standard or commonly accepted BAC. To be in class C minimum building automation and control functions that could be defined on a national level shall be implemented.

- Class B corresponds to advanced BAC and some specific TBM functions. To be in class B it is required that room controllers shall be able to communicate with a building automation system.

- Class A corresponds to high-energy performance BAC and TBM. To be in class A, room controllers shall be able for demand controlled HVAC (e.g. adaptive set point based on sensing of occupancy, air quality, etc.) including additional integrated functions for multi-discipline interrelationships between HVAC and various building services (e.g. electricity, lighting, solar shading, etc.).

A reference list of BAC functions defining minimum requirements of BAC functions according to BACS efficiency class C is given in EN 15232. Unless differently specified this list shall be used:

- to specify the minimum functions to be implemented for a project;
- to define the BAC function to take into account for the calculation of energy consumption of a building when the BAC functions are not defined in detail;
- to calculate the energy use for the reference case in the BAC efficiency factor method.

Both energy consumption of the building as well as indoor conditions are depending on CONTROL ACCURACY which is the degree of correspondence between the ultimately controlled variable and the ideal value in a feedback control system. The controlled variable could be any physical variable such as a temperature, humidity, pressure, etc. The ideal value is in fact the SET POINT established by the user (occupant) when he determines his level of comfort. It is clear that the entire control loop is concerned with all the elements constituent, such as sensors, valves and actuators. The impact of BAC functions on the annual energy use of a building can be calculated within the EPBD simulation environment by either a detailed method or a so-called BAC factor method. The detailed method models physical effects in the HVAC control loops in very detail thus requiring lot of technical information about the system configuration and its control algorithms while the BAC-factor method is simplifying this approach for practical estimation taking into account typical building and HVAC configurations.

At this time one has to keep in mind that EPBD calculation approach is based on DEMAND ORIENTED CONTROL. Usually these strategies implement the direction of the energy flow (from GENERATION to EMISSION) with flow of calculation (from building needs to delivered energy). Usually for this complex CONTROL STRATEGY, a TBM is necessary with a distributed specific control for each Technical Building System who communicates in system architecture. More clear, this Demand Oriented Control works as follows: When the comfort is reached in the Emission area, the controller from the Emission sent the message to the controller in charge of Distribution to stop to distribute energy, who sent the message to the controller in charge of Storage either to store the energy and if the Storage cannot store more energy sent the message to the controller in charge with the Generation to stop to generate more energy.

In addition to that a Technical Building Management System may be installed in reality (depending on the size of the building and complexity of the management task) if several Technical Building Systems are used in the building. Specific global functions are implemented here, necessary to reach the key-role mentioned above. Usually, in this case, an interrelation with the Building as such will occur, mainly to take in consideration the building needs; for example, due to outside temperature, taken into account the inertia of the building when the control will reach the set point in a room. BAC orchestrated by TBM will allow for the global optimization of the Building Energy Performance. Therefore, a CONTROL STRATEGY is applied to reach a goal. Optimal control strategies deliver a desired level of control at a minimum cost. A CONTROL STRATEGY could consist by a CONTROL FUNCTION or a group of CONTROL FUNCTIONS.

A new standard EN 16947 has been established under the M480 to address the TBM/BMS functions. This new standard covers several functions of the application of the Building management system. Each function is represented by at least one calculation method. The functions are as follows:

- "Function 1 – set points", is meant for set point definition and set back. An example of a CONTROL STRATEGY consist by a CONTROL FUNCTION is OPTIMUM START, OPTIMUM STOP, Night SET BACK described in the standard EN 12098.
- "Function 2 – run time" is intended for estimating run times. An example of a CONTROL STRATEGY who is realized by a group of CONTROL FUNCTIONS is the CONTROL STRATEGY used by INTERMITENCE. This function uses several CONTROL FUNCTIONS, OPERATION MODES, OPTIMUM START-STOP and TIMER in same time. All elements together are called either Building Profile or User Pattern. Usually, to implement such Building profile, a TBM is a prerequisite.
- "Function 3 – sequencing of generators" is intended for estimating the sequential arrangement of different

generators. Generators are either from same type (e.g. several boilers) or different types (e.g. a boiler and heat pump) including also the Renewable Energy Sources. The strategy could be based as follow:

- Priorities only based on running time;
- Fixed sequencing based on loads only: e.g. depending on the generators characteristics, e.g. hot water boiler vs. heat pump;
- Priorities based on generator efficiency and characteristics: The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. solar, geothermic heat, cogeneration plant, fossil fuels);
- Load prediction based sequencing: The sequence is based on e.g. efficiency & available power of a device and the predicted required power.

- "Function 4 – local energy production and renewable energies" is intended for managing local renewable energy sources and other local energy productions as CHP.
- "Function 5 – heat recovery and heat shifting" is intended for shifting thermal energy inside the building.
- "Function 6 – smart grid" is meant for interactions between building and any smart grid.

In general functions could be used independent from each other depending on the BMS features installed in the building. Nevertheless, in some cases methods do represent different levels of similar function and will reference each other. It is worth to mention that impact of both BAC functions by detailed method described in EN 15232 and BMS functions described in EN 16947 on the energy performance of a building can be quantified only in case detailed information about the building, the HVAC system and especially the type of automation, control and management functions is available that can be applied in a holistic EPB calculation method. The method should be used only when a sufficient knowledge about automation, control and management functions used for the building and the energy systems is available. The application of the calculation procedures implies that all automation, control and management functions that have to be account for the operation of a building and its energy systems are known.

In at least any other cases the BAC factor method is a valuable alternative. ■

References

EN 15232-1 Energy performance of buildings - Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10.

EN 16947-1 Building Management System - Module M10-12 and the connected TR's: CEN/TR 15232-2 and CEN/TR 16947-2.