Towards nZEB with BAC

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The Energy Performance of Buildings Directive (EPBD recast) is a very important step in the effort of the European Union to improve the energy efficiency of the large building stock in Europe, and to establish Energy Performance levels requirements for the new buildings, opening the route towards nZEB, and reduction of CO_2 emission as well. This implementation of EPBD recast will lead to the final goal for the occupants of the buildings by offering a healthy and productive environment at their working places and in their homes. One of important issues raised in EPBD recast is the concept of nZEB. It is the intention of this article to describe ways to reach this goal and the contribution of BAC for Energy Performance of Buildings in general and for nZEB in particular. The focus of this article will be to show the place BAC in the EPB standards developed under EU Mandate 480, work carried out by CEN/TC247 in charge for BAC within this Mandate.

In this article: BAC stands for Building Automation and Control and nZEB stands for Nearly Zero Energy Building (as given by the EPBD (2010/31 / EU) in article 2)

Various indicators and requirements are to be combined to meet the definition of a building with energy use of almost zero (nZEB), a building that has a very high energy performance determined in accordance with Annex I of the EPBD.

Under Mandate 480 given to CEN, about 40 EN standards were updated, merged or developed to harmonize the energy calculation methods for buildings within Europe. This is to increase the transparency and coherence of the calculation methodology used today and tomorrow within the European countries. BAC (based on the standards developed by CEN/TC247) contributes with 7 standards and 7 Technical reports. The main standard is EN 15232 which includes a comprehensive and structured (for calculation methodology) list of BAC functions that are intended to be used in the whole EPBD Standards set. Where the contribution of BAC in all modules of the new MODULAR STRUCTURE OF EPBD Standards Set is applicable. BAC is identified as Module M10 and covers the modules M10-1, M10-5, M10-6, M10-7, M10-8, M10-9 and M10-10 vertically, but consistently will be present in ALL Modules Mx-5, Mx-6, Mx-7 and Mx-8.

Improved energy efficiency in buildings is a high priority among European decision makers, as well as building owners. Presently there is one European standard that assists building owners to ensure that a new building being built, or an existing building being refurbished, will have the best available BACS technology to save energy – i.e. the EN 15232 – Energy performance of buildings – Impact of Building Automation, Controls and Building Management standard. Two standards (EN 15500 and EN 12098-x) complete the set of functions of EN 15232 and give the CONTROL INPUT DATA for other modules. For BAC standards, the set is completed by new subjects: Contribution of Building Management System (or Technical Building Management TBM) to optimize the energy use of technical building systems and the Inspection for Building Automation and Control. BAC performance has a tendency to decline over time if not actively checked, maintained and adapted to the actual use of the building (independent of the building type).

However, there are no standards available that address the difficult challenge of building owners to ensure that their buildings keep performing as well over time, or better, comparing to the performance when they were first commissioned.

Insight nZEB

Different requirements are combined to a coherent assessment of a nearly Zero-Energy Building (nZEB).

A nZEB means a building that has a very high energy performance (very low amount of energy required associated with a typical use of the building including energy used for heating, cooling, ventilation, domestic hot water and lighting), taking into account:

- indoor environmental conditions;
- thermal characteristics of the building, building elements having a significant impact on the energy performance of the building envelope;
- HVAC installation, domestic hot water supply, built-in lighting installation, optimizing the energy use of technical building systems through BACS;
- active solar systems and other systems based on energy from renewable sources;
- district or block heating and cooling systems.

The very low amount of energy required by a nZEB shall be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.

Globally, we could identify 3 requirements in the assessment methodology step by step 'from the energy needs to the overall energy performance expressed in primary energy use'.

Only if the requirement of each step is reached, then the building can be qualified at the end as 'nZEB'.

The three requirements are:

- The building fabric (Energy needs) reflecting the performance of the building fabric characterised by the energy needs. The energy needs are based on local conditions and the designated function of the building and the need to guarantee adequate indoor environmental conditions in order to avoid possible negative effects such as poor indoor air quality (due to lack of ventilation) or hydrothermal problems (such as mould).
- The total primary energy use The second requirement is reflecting the performance of the technical building systems (HVAC installation, domestic hot water supply, built-in lighting installation, BAC) characterized by the energy use.

Technical buildings systems are linked to one or more energy carrier (e.g. gas boiler; auxiliary consumption). To add the different energy carriers in a coherent manner the second requirement is expressed in total primary energy.

- Non-renewable primary energy use without compensation between energy carriers

The third requirement is reflecting the contribution of energies from renewable sources (e.g. active solar systems or other systems based on energy from renewable sources, district or block heating and cooling systems) characterized by the non-renewable primary energy consumption

Insight BAC

The key-role of Building Automation and Control and BMS is to insure the balance between the desired use of a zone, human comfort and desired productivity of humans working/living in zones - which must be optimal, and energy used to obtain these goals - which must shall be minimal!

The scope of BAC and TBM covers in accordance with their role from one side all installed and involved Technical Building Systems (where the effect of the BAC is used in the calculation procedures) and from another side the global overall optimization Energy Performance of a Building.

We could identify several categories of controls:

a) Technical Building Systems specific controls; these controllers are dedicated to the physical chain of transformation of the energy, from Generation, to Storage, Distribution and Emission. We find them in the modular structure of EPBD Standard Set matrix starting with the Modules M3-5 to M9-5 and finishing with M3-8 till M9-8. We could consider that there exist one controller per module or several modules. More often, these controllers are communicating between them via a standardized open bus, such as BACnet, KNX or LON. Control functions may reside in products or components which are described in EN ISO 16484-2, -3 and -4.

b) BAC controls function to coordinate among different building services like BAC used for all or several Technical Building Systems who do multidiscipline (heating, cooling, ventilation, DHW, lighting…) optimization and complex control functions. For example, one of them is

   – INTERLOCK, a control function who avoids heating and cooling in same time

   – COORDINATION of "light & blind & HVAC" control systems that can result in optimization of light emission in zones (mix of daylight and artificial light)

   – ENABLING users to access set point adjustments that avoid infringements between e.g. heating and cooling set points

c) If all Technical Building System are used in the building, we have (depending of the size of the building) a Technical Building Management System. Specific global coordination functions are implemented, necessary to reach the key-role mentioned above. Usually, in this case, an interrelation with the Building as such (Module M2) 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.

In a Control System dedicated to a Building, who is BAC and TBM we can distinguish three main characteristics:

1° 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 its active elements, such as sensors, valves and actuators. Specific equipment will require a specific controller. For hydronic systems, like the energy carrier hot water, an important issue is the balancing of the hydraulic circuits. For that purposes, balancing hydraulic valves are needed.

The Control Accuracy for a temperature is defined by two components: The temperature Control Accuracy (CA) is dependent upon Control Variation (CV) and Control Set point Deviation (CSD) as described in the main text of the standard prEN 15500:2014. The compliance with CA is also defined in the standard. This is an important input for prEN 15316-2, where the effect of the control for heating, cooling and ventilation is taken into account. The same standard (prEN 15500:2014) describes also the 4 operations modes who deal with the levels of temperatures: Comfort, Pre-comfort, Economy and Frost Protection. These 4 predefined operation modes are parameters that could be set by the users (occupant) – the temperature allocate to each operation mode. These operations modes are important for the control strategy used for intermittence, which will be described below.

2° CONTROL FUNCTION is the ability of a controller (or set of communicative controllers) to perform a determined task(s) – as described in ISO 16484 series of standards. Usually the functions implemented in the controllers are parametrable or free programmable. The functions could be performed by a single controller or by a set of communicative controllers. A controller could perform several functions.

The CONTROL FUNCTIONS present in a BAC or TBM, are present in prEN 15232:2014 Table 1 in prEN15232 starts with Heating Emission, Distribution, Storage and Generation (M3-5, M3-6, M3-7, M3-8) follow by Domestic Hot Water, Cooling, Ventilation and Lighting (M9-5, M9-6, M9-7, M9-8). 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 each function, an IDENTIFIER who is the software language for BAC and TBM is also defined, as the destination of the module where the control function gives his effect.

An example is given in **Table 1**, as abstract from prEN 15232:2014:

Table 1. Example of the CONTROL FUNCTIONS organized in the matrix given by Modular Structure of EPB standards.

Automatic control		
1	**Heating control**	
1.1	**Emission control**	HEAT_EMIS_CTRL_DEF M3-5
		The control system is installed at the heat emitter at room level (radiators, fan-coil unit, indoor unit), for case 1 one system can control several rooms
	0	No automatic control of the room temperature
	1	Central automatic control: There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3
	2	Individual room control: By thermostatic valves or electronic controller
	3	Individual room control with communication: Between controllers and BACS (e.g. scheduler, room temperature set point)
	4	Individual room control with communication and presence control: Between controllers and BACS; Demand / Presence control performed by occupancy

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.
- Class C corresponds to standard BAC.
- Class B corresponds to advanced BAC and some specific TBM functions.
- Class A corresponds to high-energy performance BAC and TBM.

Having a poorly performing building/installation due to a lot of reasons, and mainly due to the inconsistency between the key phases of the construction (retrofit) a building which is design, commissioning and use, we have to realise that the BAC and TBM cannot change a bad building service design into an efficient operation!

Unfortunately (and this happens too often), the worst case (**Figure 1**) is when:

- What was DESIGNED
- What was INSTALLED
- What was planned as USE

ARE DIFFERENT FROM ONE STEP TO ANOTHER!

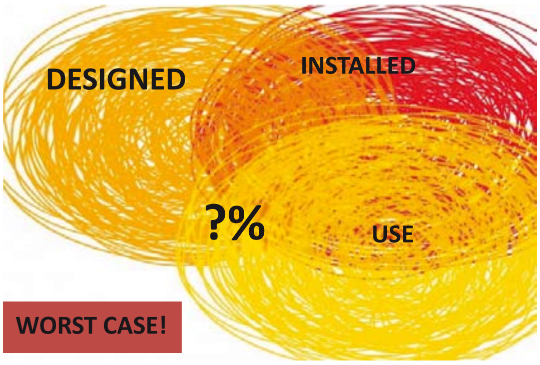

Figure 1. The worst case.

3° CONTROL STRATEGY is the set of methods employed to achieve a given level of control 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.

An example of a CONTROL STRATEGY consist by a CONTROL FUNCTION is OPTIMUM START, OPTIMUM STOP, Night SET BACK described in the standards prEN 12098-1 and prEN 12098-3. The Timer function is described in prEN 12098-5.

Another example of a CONTROL STRATEGY 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 FUNCTIONS the same time. All elements together are called either Building Profile or User Pattern. Usually, to implement such Building profile, a TBM is a prerequisite.

The most important CONTROL STRATEGY described and implemented in prEN 15232:2014 is DEMAND ORIENTED CONTROL. Usually these strategies implement the sense 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 via a communication standardized bus such as BACnet, KNX or LON.

More clear, this Demand Oriented Control works as follows:

- when the comfort is reach 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.

Another important Control Strategy is the control strategy for multi generators 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

The standards enabling to calculate the effect of BACS and TBM functions on energy consumption use different approaches to calculate this impact:

- direct approach;
- operating mode approach;
- time approach;
- temperature approach (control accuracy);
- correction coefficient approach.

Implementation of the BAC standards by BAC industry

NSB's (National Standardization Body's) disseminate the BAC-EPB standards, the BAC manufacturers are heavily influence their own R&D programs and production to implement the CEN/TC247 standards across Europe and worldwide. The BAC standards are rolled out to the market place and which supports the transparency and visibility of the whole building construction chain starting with specifications for design, commissioning and use. This should be done for the full buildings live cycle starting with new constructions and existing buildings, using upgrading, evolution, and retrofit techniques for the BAC Systems.

Industry associations such as Syndicat ACR in France or eu.bac (European Building Automation and Control Association) in Europe support this action and have dissemination programs for the implementation for the usage of these standards to fulfil the requirements of the EPBD recast and National Regulation. This also means that there a strong wish of the BAC Industry that the activities such as regulation, standardization, certification and labeling use the same references to describe BAC Systems. This means in practice that the BAC standards could be used and referenced in National Regulation and also be a bases for EU Certification and EU Labeling.

We could mention two important initiatives of eu.bac on EU level who is the eu.bac Certification and Labeling Scheme (in place from 2005 with more than 200 public domain certificates based on EN 15500) and eu.bac system based on EN 15232.

A small description of the goals of eu.bac system and the relation between EPB and BAC systems are shown in **Figure 2**.

Conclusion

This article explains the assessment of a nZEB building (the 3 levers who must be reached all at same time) and the key-role of BAC for EPB with his techniques. The BAC Standards issued by CEN/TC247 will be rolled out in Europe. The BAC Industry Associations have dissemination programs to implement the standards as support of regulation, certification and labeling.

nZEB is a challenge of a near future (2020). The use of the holistic approach of EPB Standard Set (including the BAC standards) is an eminent approach. Higher performance requirements regarding the building fabric, the technical building systems and the use of

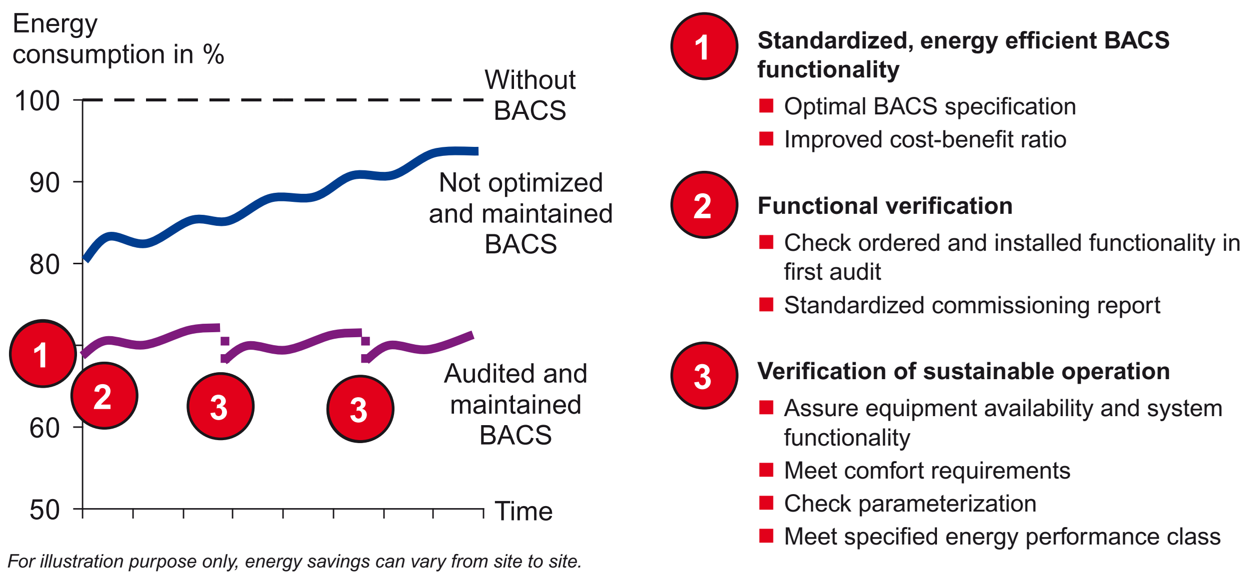

Figure 2. A small description of the goals of eu.bac system and the relation between EPB and BAC systems.

energy mix that will include more renewable energy. This means that the building becomes more and more interactive with his external environment and changes its traditional behaviour from a "passive consumer" to an active partner to the grids. The building becomes "intelligent or smart" interacting with "intelligent or smart grids". With this evolution from both sides, the target of nZEB could be reached where BAC is considered to be the key element.

So, we could conclude that towards nZEB we must more and more pay attention to BAC! ■

References

CEN/TC247 document prEN15500:2014

CEN/TC247 document prEN12908-x:2014

CEN/TC247 document prEN15232:2014

CEN/TC247 document BMS

CEN/TC247 document Inspection

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