Problems of Technology of Energy-Saving Buildings and Their Impact on Energy Efficiency in Buildings

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Abstract. Introduction of EPBD in legislation of the EU member states caused that buildings must meet very stringent requirements of thermal protection and energy efficiency. On the basis of EPBD provisions, EU Member States introduce standard of NZEB (Nearly Zero-Energy Buildings). Such activities cause a need for new, innovative materials and technologies, and new approaches to design, construction and retrofitting of buildings. Indispensable is the precise coordination of the design of structure and technical installations of building, which may be provided in an integrated design process in the system BIM. Good coordination and cooperation of all contractors during the construction phase is also necessary. The article presents the problems and the new methodology for the design, construction and use of energy efficient buildings in terms of energy saving technologies, including discussion of the significant impact of the automation of technical installations on the building energy efficiency.

1. Introduction
Requirements to ensure high energy efficiency of the buildings resulting from EPBD and put new challenges ahead of architects and designers. Energy efficiency of a building depends on four factors:

- quality of the materials and construction solution of the external wall of a building,
- technical installations of a building, such as sources of acquiring, producing, distributing and using energy, and
- way of using a building and its resources.

The fourth, at first glance invisible factor, closely related to the technical installations of a building and the way it is used in are systems of automation and control of all technological installations of a building (Building Automation and Control System - BACS), and also systems of technical management of the building (Technical Building Management – TBM). To ensure high energy efficiency of a building and at the same time to provide comfort of usage, it is indispensable not only to use proper construction materials but also adequate technological installations that would make possible an energy distribution control according to the current requirement for the specific forms of energy in particular rooms of a building, in detail defined in PN-EN 15232 standard. The most important conclusion of standard [1] recommendation may be the statement that the influence quality of the automation and control system (BACS) and technical building management (TBM) directly depends on proper construction of the basic installations of a building, which have a decisive influence on the consumption of different energy forms. Details of these dependencies are widely presented in
To get the biggest influence of the BACS and TBM systems on the energy efficiency of a building, such a construction of technological installations is necessary that would allow to control supply of every form of energy individually to each room depending on the demand. The energy demand and supply model of example technical installation of energy generation, distribution and consumption including the demand control is presented in Figure 1 [1].

![Energy demand and supply model](image)

**Figure 1.** Energy demand and supply model (Example: Heating plant) [1]

To achieve such a model of installation it is very important to ensure cooperation of all technological installations in such a way that they all would cooperate in saving energy. Especially important is the integration on the object level of automation installation of particular technological installations with safety systems installations, which provide information about the users’ presence in the rooms and thanks to it allow an accurate control of energy supply depending on the demand. Such a simple requirement causes very fundamental changes which have to be applied in the preparation and designing process of the investments meeting strict requirements in respect of energy efficiency. Due to the necessity of complex attitude to the designing process a new methodology of integrated building designing is needed, what certainly BIM (Building Information Modelling) methodology brings into designing.

2. Traditional building design process

In a traditional building design process, specific energy efficiency requirements are often not taken into account, apart from the requirements defined in present technological conditions specified by the
applicable building law. After fixing the functional and usage programme and architectonic vision there follows a process of multi-branch designing which should be coordinated by the architectural office conducting the project. All branch installations, such as power supply installation, heat and coolness source, domestic hot water installation, ventilation and air conditioning, lighting and shading systems and also safety and security systems are designed by branch designers, often with minimum information exchanged among one another. In result of this process the system of building management (BMS) integrates the functions resulting from branch designs, but the branch designs themselves do not take into consideration the necessity of interdisciplinary cooperation. With such a classic attitude to design it is difficult to speak about realisation of a specified energy efficiency (performance) of a building, it is rather possible to speak about result efficiency which is in fact a random one.

3. Integrated design process oriented towards achieving a specific energy performance of a building

In order to obtain a specific energy performance of a building it is necessary to change not only the attitude to the design process of the construction elements and technological installations of a building but also to the automation and control system, and the system of technical management of a building, as well. It is necessary to combine the decisions referring to the construction solutions applied in technical installations of a building in such a way as to make these installations control the supply of any form of energy individually for each room, depending on the demand, because it is only then, according to [1], that the maximisation of automation influence on energy efficiency of a building is possible. The whole process of a building design should be strictly subordinated to achieve a specific, set energy efficiency of an object. This process should be started on the level of an investor and architect from setting an intended energy performance of a building at the stage of defining investment intensity. When working out the programme of function and usage of a building, defining functions of the rooms and their technical equipment, such functionality of technical installations should be assumed that would allow to meet the requirements included in [1]. On the basis of the building energy simulations [7] required of BAC and TBM systems on energy efficiency should be defined. The choice of the target energy efficiency of a building is of fundamental importance for the whole further process of designing, the structure of a building and technological installations and functionality of BAC and TBM systems. This decision has an effect on:

- technology a building is realized; it must meet particular demands indispensable to achieve high energy efficiency,
- choice of technical installations functionality making possible the realization of automation and control functions systems BAC and TBM,
- necessity of realization specified functionalities through automation and control systems (BACS) and technical management of a building (TBM), what automatically means a definite construction of technological installations, allowing the application of demand control of energy consumption,
- designs and construction of all branch technological installations which have to make realization of specified automation and control functions possible,

The result of an integrated design process is achieving such technological installations functionality, automation and control (BACS) and technical management of a building (TBM) systems that would guarantee set and planned influence class of BACS and TBM systems on energy efficiency of a building.
The basic condition to achieve such a result is to include a designer of automation branch at a very early stage of designing, already at the phase of defining functionality of the systems and technological installations. Functionality of technological installations decides whether it would be possible to use specified functions of BACS and TBM, which in turn determine adherence of automation system to a specified class on energy efficiency and finally guarantee the highest impact on the building performance.

4. Perspectives of BIM method application in the integrated design process of a building oriented to gain a specified energy efficiency of a building

A solution guaranteeing realisation of integrated design process is BIM (Building Information Modelling) technology which offers not only the effectiveness of the design process itself, but also guarantees integration of this process at every stage, what is an indispensable condition for designing a building of NZEB class.

There are many definitions of BIM, but the key to differentiate them from 3D CAD is the information possessed by the model. In the BIM process such information can be available to in proper time. In this aspect, BIM allows to eliminate repetition of work at each stage of the life cycle of a building.

An integral part of a low energy building design is its precise energy model. What is modelled is both energy demand for heating, cooling, ventilation and lighting of the buildings as well as exploitation parameters in order to optimize the architectonic or installation solutions of the designed object. Creating energy model of a building shows similarity to the modelling process in which a graphic model is analysed.

One can notice some similarities between low energy buildings and BIM:

- designing and the process are of essential importance,
- information, technical parameters are the most important, architectonic visualisation is not enough,
- carrying out analyses, testing solutions are of key importance; graphic model is to verify the accepted assumptions.

Assuming that the inter-business cooperation is realised within the frames of Open BIM – an open workflow, useful for the designer responsible e.g. for energy analysis of the object is an architectonic-construction model of a building containing proper information about the technical parameters of the partition layers/ envelope layers. As a result of the data imported from the IFC (Industry Foundation Classes) file to the programme used in carrying out energy analysis of a building it is useful to automatically calculate heat transfer coefficient for given partitions in agreement with the Polish norms and regulations. Thus, the process of calculating the designed heat load of a building is improved.

Utilizing a geometric model in the design process of a low energy building makes it possible to verify the design visually in terms of heat loss through the partitions and thermal bridges. It also allows an effective inter-business coordination in order to check possible collisions. Lack of coordination may cause, among others, unexpected heat losses, increase of energy consumption, CO2 emission, increase of the risk of steam condensation in a given partition.

Geometric model is also used to generate numerical data in real time, e.g. the volume of ventilation air, room dimensions and their air space, heat losses of particular rooms and partitions.
What results can be obtained in the process of designing buildings of near-zero energy consumption?

A precise energy model makes it possible to avoid oversizing heat source power of a building. It is essential that the required energy characteristics of a building were formed already in the concept phase of a building block. This would allow possible minimization of A/V aspect ratio (decreasing the surface of external envelopes in relation to the cubature). In realizing the concept of a low energy building it is favourable to use innovative technologies such as systems supporting mechanical ventilation with heat recovery, e.g. ground/earth air heat exchanger (gravel, plate, glycol, tube), photovoltaic installation, heat storing systems (e.g. using phase change materials), active and passive solar systems and the like.

The experience of implementing BIM in Great Britain shows a positive integration of the designing processes of passive and BIM buildings, which may be used to verify the model visually and to generate numerical data in real time. Thanks to it the designing process becomes efficient and the inter-business cooperation more effective. Building energy efficient, low energy and passive buildings contributes to radically lower energy consumption, CO2 emission on a global scale and allows to achieve a high comfort in their usage.

It is worth remembering that the software should not determine the aim of design activities. It is the engineers understanding the concept of sustainable development that should seek how to make an effective use of the BIM process in the realised investments. The key aim of the BIM can be seen in its implementation by the specialists in object management.

![BIM process phases](image)

**Figure 2. BIM process phases**

5. **Conclusions**

The considerations presented above show that achieving a specified energy efficiency of a building depends on many factors, but the key to reach the target is to use a new approach to the design process of a building. Energy performance of a building depends not only on the used material and construction solutions, but also on the technological installations of a building, which are able to ensure maximum influence of automation and control systems on energy efficiency of a building.
according to PN-EN 15232:201 standard. Automation and control systems (BACS) and technical management of a building (TBM) themselves would not ensure high energy efficiency of a building if technological installations would not allow it. This means that a radical change of attitude to the design process of a building is necessary. First, in the initial stage of designing, after having chosen a desired energy efficiency of a building, a simulation should be carried out in order to determine the necessary degree of influence of the BAC automation and technical management of a building (TBM) systems on the total energy efficiency of a building. On the basis of these simulations [7] there should be chosen a specific and for application indispensable influence class of BAC and TBM systems. This choice indicates the way of necessary realisation of particular technological installations which have to be vulnerable. The role of a designer of automation system cannot be limited to working out automation for already designed technological installations (what is at present a standard design practice the whole process of designing technological installations and their control and management systems has to be subordinated to this definition. This entails that on the basis of investor’s decision about the expected energy efficiency of a building of BAC and TBM systems on energy efficiency, automation designer has to be included right from the beginning into a design process, has to participate in formulating assumptions for technological installations designers and coordinate the designed solutions in respect of their susceptibility to integrated control, indispensable to achieve proper influence of BAC and TBM systems on energy efficiency, and not, as it had been before in a designing practice, to subordinate to the branch designers’ demands.

An effective tool ensuring an integrated process of Nearly Zero Energy Buildings is BIM, thanks to which the participants of the design process have permanent access to the data that interest them. Creating low energy building fits into the concept of BIM due to the necessity of its accurate analysis already in its conceptual phase. Thanks to it inter-business integration is being realised right from the beginning of the realisation of a given investment. It should however be stressed, that the keys to the success are: conscious decision of the Investor on the intended energy efficiency of a building and a consequently applied integrated design process subordinated to the Investor’s decision.

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