Intelligent Building Commissioning for EPBD Certification Support in the Czech Republic

Karel Kabele
Professor

Lukáš Emingr
PhD candidate

Department of Microenvironmental and Building Services Engineering
Faculty of Civil Engineering CTU in Prague,
Thákurova 7, 166 29 Praha 6, Czech Republic
e-mail: kabele@fsv.cvut.cz; lukas.eming@centrum.cz

ABSTRACT

Building commissioning is a developing concept also in the Czech Republic. At present time only some aspects of building commissioning are implemented as a part of the facility management and energy auditing processes that are related to EPBD implementation. The project, presented in this paper, aims to find ways of energy-efficient operation of existing and designed energy-efficient buildings and is based on the fact that many buildings designed according to modern principles, in its operation does not behave as expected. The project is investigating and developing procedures to help change the current often intuitive approach to operate buildings in a systematic activity, taking into account energy conservation. Modern control systems of intelligent HVAC buildings could provide not only the information needed for the operational control of building, but also to detect faults and to evaluate the energy performance of the building. Under the IEA Annex 47 project, authors started to develop tools that support additional aspects of the commissioning process, including new control system for building energy services. The paper is focused on specification of new function of building control system, providing information for existing building EPBD certification. Results in terms of implementation of this function into existing building energy control system are discussed.

INTRODUCTION

The question of building commissioning is in the Czech Republic discussed particularly in connection with the efforts to reduce energy requirements of buildings, increased requirements on the quality of the internal environment in buildings and in connection with requirements on efficient management. However, activities related to the aspects of operation of buildings and building technical systems are in the Czech Republic partially carried out as a part of operation and maintenance of buildings and building technical systems in the context of existing procedures of facility management, energy audit processes and within the framework of implementation of Directive on the Energy Performance of Buildings. Thanks to the principles of measurement and methods of comparing measured values with computational models of buildings, Building commissioning is also a tool allowing quantification of errors in the calculations of energy requirements as compared to the real performance.

IMPLEMENTATION OF EPBD AND EPBD RECAST

It was agreed that the Directive on the Energy Performance of Buildings 2002/91/ES has been implemented in national legislations of the member states from January 1th 2008. In the Czech Republic this directive was implemented in the national legislation by Act No. 406/2000 Col., on Energy Management, as amended, as well as by decrees No. 148/2007 Col., on the Energy Requirements of Buildings [MPO 2007], No. 277/2007 Col., on the Control of Air-conditioning Systems and No. 276/2007 Col., on the Inspection of Boiler Efficiency. The aim is to reduce overall energy requirements of buildings in economical way, taking into consideration national and local circumstances. The Directive establishes general aims and the main principles of efficient use of energy in buildings. The above rules and regulations establish energy requirements of buildings and all energy systems within buildings. Only decrees 277/2007 Col. and 276/2007 Col. define in simple way rules for inspection of air-conditioning systems and boilers burning solid, liquid and gas fossil fuels. They also prescribe time intervals between inspections in these facilities and method of documenting inspections. With respect to the current trend of using low-emission and renewable sources of energy it is suitable to implement further decrees and legislation for these sources of energy.

In the Czech Republic there are currently several groups working on the amendments for the corresponding legislation so that the duty to implement in due time the EPBD recast [EPBD 2010] directive would be fulfilled. The EPBD recast was extended using conclusions yielded from several years of experience with the original EPBD directive. Currently the main aim for these work groups is to come to an agreement on what the common solution should be and lay down groundwork for the amendment to the decree 148/2007 Col., on the Energy Requirements of Buildings, including the necessary amendments to related documents, in particular to Act No. 406/2000 Col., on the Energy Management [MPO 2007]. These proposals and recommendations should include not only measures related to building constructions, their thermal technical parameters and properties, but also new recommendations for the operation of energy systems (HVAC), methods of their operation and measurement of efficiency of

this operation [Kabele, K, Urban, M, Adamovský, D, Kabrhel, M. 2010].

The aim the Czech Republic must achieve is the implementation of the duty to construct buildings with near-zero energy consumption by December 31st 2018 in case of buildings used and owned by public authorities and December 31st 2020 for other buildings. The corresponding work groups are working on the concrete definition of a building with near-zero energy consumption. It is clear that besides very low energy requirements of the building (so not just small heat consumption) it will be necessary to use renewable sources of energy and thus minimize the primary energy consumption. It is also certain that sudden requirement of near-zero energy performance in new buildings in 2018 and 2020 would be a great shock for the entire building market, therefore a solution will be proposed, which would slowly prepare the developers for near-zero energy buildings in gradual steps.

The impact of EPBD so far has been limited to the sector of new buildings and large reconstructions. Amendment to EPBD certification will bring about one fundamental change – extension of some recommendations and requirements on all objects when under reconstruction, as well as in the moment of sale or lease. In case of public buildings the limiting value for elaborating and posting the certificate on a visible place is 500 m^2 of surface area. Starting from July 9th 2015 this value will be reduced to 250 m^2. Further changes that will result from EPBD will be related to the inspection of boilers and air-conditioning systems.

In the context of these preparations of changes in the Czech legislation it is suitable to implement in the new modifications also recommendations for correct and efficient methods of putting building technical systems into operation.

COMMISSIONING IN THE CZECH REPUBLIC

In comparison with other countries around the world there are currently no national programs or activities of national energy institutions in the Czech Republic, which would allow for at least voluntary participation in programs of correct methods of putting energy systems into operation and their efficient and long-term operation. Initiative related, among others, to the implementation of the EPBD recast should be directed towards creating unified manuals, tools and elaboration of relevant suggestions, which would facilitate the process of optimization of building operation, as well as education system and creation of information programs focused on dealing with the needs of building owners, putting building technical systems into operation and their optimal operation sustained in the long run. Much is expected from envelope constructions, use of renewable resources and reduction of CO_2 emissions, but this topic must also cover systems capable of providing long-term functionality of buildings and adequate working environment with respect to effective use of all installed systems. A certain motivation is the possibility of considerable energy savings that will help to achieve the goal – reduction of energy consumption in EU member states by 20 % by the year 2020 as compared to 1990.

The essence of commissioning is known in the Czech Republic, but until now it has been perceived only as a part of facility management and building maintenance. The process that guarantees the quality of installations, constructing building technical systems in objects and their correct activation is a systematic activity that includes testing, measuring and documenting, which leads to correct proposal for all installed systems in a building and their optimal use respecting operational requirements of the building and its future owner or operator.

Main use of commissioning and implementation of procedures in practice

- Improved understanding of proposed designs within building technical systems and optimization of the operation of existing systems
- Earlier transfer of operational responsibility to the operating team (FM)
- Confirmation of coordination plans of constructions
- Improved quality of output (revision) building documents
- Continuous monitoring of the expected values related to building technical systems
- Documenting (measuring) of the quality of air in internal environment and control of user comfort
- Help in achieving planned dates of moving in and putting systems into operation
- Allowing the owner to understand capacities and limitations of the built-in systems
- Transfer of experience from operation of systems back to the planning phase
- Help in creating new legislation related to facility management and putting building technical systems into operation
- Improving the quality of training for the operating personnel
- Opening communication channels between individual branches of the buildings production process and thus also between the owner of a building, architect and planner, operator and user
- Improving computer programs for operation and maintenance
- Measurement of the values necessary for verification and comparison with calculations of EPBD certification.

CURRENT SOFTWARE SUPPORT FOR FM AND COMMISSIONING IN THE CZECH REPUBLIC

Company information systems

Especially foreign companies active in our market control their resources by complex company information systems. The largest and most complicated are referred to as ERP (Enterprise Resourcing Planning), the most renowned in the Czech Republic are SAP and J.D. Edwards. Systems of this type record, analyze and control the functioning of companies, provide overview of production, financial and human resources and are also capable of controlling them. However, these systems can relatively easily be used also in controlling support activities of facility management. The advantage of these systems is their comprehensiveness, in particular their ability to cooperate with company's accounting and financial systems. A big disadvantage is their price, complexity and lack of

flexibility when used for the needs of service and maintenance technicians, who require simple, graphically friendly software without much time requirements. Their use in acquiring information not only for the control of operation but also for detecting errors in the assessment of energy requirements is not common in the Czech Republic.

CAFM = Computer Aided Facility Management software

This is the most common tool used in the Czech Republic for facility management and control of support processes. Just like other ICT systems used mainly as a support for decision-making of clients (managers), planning and control, in this case it is control in the area of FM. CAFM system in organizations are used mainly by the top management to create strategies, by the middle management for tactical management with the aim of optimizing (reducing) costs of operation and increasing the quality of services provided, as well as for operational control of HR and processes. It is a type of application, which combines information database system with graphical interface.

The aims of implementing CAFM systems are in particular:

- Reduction of the costs of operation (by as much as 30 %)
- Increasing the quality of services provided, increasing the quality of the environment (building technical systems)
- Optimization of the relations between employees, working environment and working processes
- Extending lifetime of the monitored objects and facilities (building technical systems)
- Implementing standards, rules and working processes in the field and in the system
- Implementing and dividing internal costs and clear attribution of these costs to departments within a company, divisions, activities, projects etc.
- Administration and updating of documentation, moving, benchmarking, inventory-taking and control
- Preparation for unexpected events and accidents, processes required by the legislation (audits, revisions,…), sustainable development
-

The advantage of these applications is their large potential and capacity to administer various support processes within the company, as well as the possibility to optimize application directly for the needs of the concrete company or operation. A clear advantage is their comprehensiveness and user-friendliness. On the other hand their high price in the Czech market is a critical disadvantage.

EAM = Enterprise Asset Management

Sometimes we also come along the term CMMS = Computerized Maintenance Management Software . Especially the second name describes well the use of this type of computer applications. It is a software application designed for the control of maintenance, which is a little bit closer to the operation and maintenance of building technical systems installed in buildings, and therefore also to the topic of this dissertation study. Such applications help to increase profitability of firms by increasing reliability of operation, efficient use of installed systems and by reducing operating costs for company's assets. EAM software tools are used by companies for controlling productivity and achieving financial results according to planned schedule (plan). This application platform allows:

- Effective use of all available resources
- Effective control of processes for the maintenance of assets
- Maintenance carried out based on current state of assets, not only in regular time intervals
- Creating scenarios for achieving optimum preventive maintenance
- Creating reports adjusted according to specific requirements
-

EAM solution is usually more than just automatic software for administration, maintenance and documenting of assets (CMMS). Very often it allows increasing transparency of the performance of companies and by thorough analysis of data reveals key trends in its functioning, as well as possible non-standard non-systematic solutions. Based on such information it is possible to exactly determine the degree of reliability in individual aspects of operation and make decisions that would in the future lead to the required financial performance. Usual tools within EAM applications are:

Work orders — planning of work activities, assigning employees to individual activities, reserving the necessary material and recording all costs

Preventive maintenance — organizing of preventive maintenance and its inspection, creating lists of required material and other related information

Asset management — recording of assets-related information, including detailed specification, information regarding guarantee conditions, servicing conditions, spare parts, data on the purchase and expected lifetime

Inventory control — administration of spare parts, tools and other material, including ordering

Advanced reporting and analysis — creating reports and analyses created to predict possible complications in the future and their prevention

A clear disadvantage of these applications is their price, especially with respect to the amount of technology these systems maintain. Very often we witness that such applications are used for the maintenance of so little technology that their advantages are not used and their installation and implementation is actually not worthwhile.

It is very difficult to choose a suitable tool that would allow discovering errors in the assessment of energy requirements of buildings from the systems normally used in the Czech Republic. We usually find strategic systems capable of maintaining assets, human resources and controlling operation and maintenance of energy systems, but incapable of working with the measured values of energy consumption. Some exceptions are used for example in automatic reading of energy consumption in parts of buildings. These applications are more suitable for planning of service, maintenance and revisions and recording their timely execution.

Systems for automatic control of buildings

If we wish to address the issue mentioned in the introduction – modern central systems for intelligent control of HVAC systems in buildings capable of providing information necessary for the operational control of buildings, but also revealing errors in the assessment of energy requirements, we need to reach into the area of intelligent electrical installations for modern buildings based on standard principles of measurement and regulation.

Table 1 Different potential of obtaining input data for energy calculations between "intelligent" and "non-intelligent" buildings

EPBD certification input parameter	Data input source	
	Building without integrated BMS] "non-intelligent:	Integrated building management system "intelligent building:
Climate data	*Databases*	*Ambient temperature, Solar radiation, Wind velocity and direction measurements*
User "load" profiles	*Standardized*	*Occupancy monitoring*
Building geometry, areas, orientation	*Drawing or direct measurement*	*Building scheme*
Building envelope constructions	*Building documentation, Building inspection*	*Surface temperatures, Indoor temperatures, Energy delivered*
HVAC systems parameters – output, efficiency	*System documentation Inspection*	*Operation temperatures, Energy delivered monitoring*
Lighting	*System inspection*	*Energy delivered, Operation monitoring*

Use of BCS – Building Control System for EPBD certification

There are BAC (Building Automation Control) and also BACS (Building Automation and Control Systems) systems capable of assessing the functionality of building technical systems based on pre-defined measurements and reporting of their limited, incorrect or interrupted functioning. In the Czech Republic they can be found only rarely, but their use in providing input information for EPBD certification is often discussed. For EPBD certification it is necessary to have certain key data on building technical systems. In particular correct energy audit and assessment of input energy for the object require precise analysis of operation. Future effort should be aimed at obtaining input values for the assessment (into energy audit, certificates of energy requirements), such that they correctly represent true efficiency of the systems in question and their operation. Some buildings in the CR, also newly built, are still operated in intuitive way, which fails to use the full potential of the systems available. Procedures of commissioning and application of BAC systems should fix this shortcoming and thus increase the efficiency of their operation. Well-planned measurement and testing of systems also allows analyzing the real heat consumption and energy used for air-conditioning and ventilation and thus also concrete inputs into energy assessment of buildings. Used in the CZ today are software applications capable of calculating the consumption of individual lease units based on measured values of the flow of heating substance. These are used mainly for automatic invoicing for heat and hot water. However, this system can be easily used for obtaining inputs into EPBD certification. The real consumption of hot water, heat, power for lighting can be sent by automatic system into the calculation tool, which analyses the true energy requirements of the given building. Such systems can be used not only in new buildings, in which they will be implemented in the future thanks to commissioning, but also in older houses, where they will reveal the main problems and places of energy leakage or inefficient use of systems [Energy Sustainability Unit NUS 2005]. The main idea of this article is based on the fact that intelligent control systems for buildings can measure values within the system and convert them into form useful for EPBD certification. From the perspective of energy auditor it will no longer be necessary to assess energy requirements (helpful especially in case of complicated heating and air-conditioning systems) and in a complicated way determine the types and amounts of energy consumed. The actual energy consumption in the object will be assessed and by optimizing individual components of HVAC systems it will be possible to significantly reduce energy requirements of buildings. It will be also possible to analyze problems in the systems much more accurately and possibly also make conclusions for new buildings. Thanks to modern intelligent control systems we can easily enter the areas of:

- Heating;
- Ventilation;
- Air-conditioning;
- Hot water generation;
- Lighting;
- Special technology units;
- Mechanical systems.

Another possible use of such control system in buildings is in controlling the process of putting building technical systems and entire buildings into operation and their subsequent optimal operation with respect to energy requirements for the purpose of achieving efficient operation of building technical systems motivated by the need to reduce operating costs. Even though standardized commissioning procedures are still far away this activity is gaining momentum [Vyskočil V. K., Štrup O. 2003].

Predictive control of buildings

Another possible use of these complicated control systems in modern buildings is in connection with procedures of predictive control. Until now buildings in the Czech Republic were controlled in traditional (sometimes even intuitive) way. And even when a measurement and control system is installed, it works based on the analysis of conditions in the building, comparison with the conditions outside and subsequent change

of parameters. The simplest example is the change of flow of heating water in case internal temperature drops below the required level (with respect to the temperature of outside air). The principle of predictive control is not only fixing existing conditions as measured in the object (temperature differences for example) but it also generates a sequence of actions, which guarantee the required parameters of the internal environment with respect to a given time interval of prediction [Frank J. H. 2001]. Based on the expected weather and climatic conditions it is possible to calculate expected future development of individual parameters and from these future values determine optimum values of action parameters. Using such systems is especially practical in larger buildings or in systems with longer reaction time (larger inertia) because in these cases such control systems allow minimizing energy requirements of heating, for example. The question remains what is the true ratio between the costs of creating such system and achieved savings in energy costs. If investment costs of such systems are reasonable predictive control of buildings, in the context of measuring and testing building technical systems, could become a popular method of reducing costs of energy, as well as lower production of greenhouse gases.

CONCLUSION

The amendment to already implemented directive on the energy performance of buildings is today a frequently addressed issue in the Czech Republic. There are also discussions on the proposed changes based on years of experience with EPBD certification. Why not using the available data also for building certification [Kabele, K., Dvořáková, P. 2007]? One of the possible future extensions of building certification that would bring it closer to the reality is obtaining input information for calculations from own systems using measurement, not just estimates and calculations. The second possibility is using the methods of building commissioning and measurements in real operations to modify methods of energy calculations and thus bring them closer to the real situation, taking into consideration the method of operating the building, aging of individual HVAC systems and also, for example, decreasing efficiency after systems were put into operation and their sustainable operation. The main result from these procedures could be proposals for changes in EPBD certification and specifications for new functional control systems in buildings. The certification still contains many generalizations, which may often significantly distort the calculated values. The basis for the implementation of this procedure is:

- testing operation of buildings that reveals errors and differences between measured and calculated values;
- collecting information from operation related to the energy consumption into central database, later to be used for optimizing the operation;
- comparison of values measured in real time and, with respect to outside climatic conditions, at given time points;
- displaying historical data, compare trends and identify corrective measures;
- creating future scenarios for better planning with predictive analyses.
- advantages and consequences of automatic acquiring of inputs for EPBD certification:
- realistic independent results;
- accuracy;
- evaluation of energy saving measures (control system set-up, solar system…);
- better comfort with lower energy consumption;
- user involved in energy saving process;
- price of the house.

"EPBD self – certification service" is than function of the building management system, integrating real measured data with building model used for energy certification purposes [Kabele, K., Dvořáková, P. 2007].

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