Energy efficiency increasing through space management. Case study in an office building*

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Abstract. *European Directives which establish energy targets for 2020 and 2030 are the main legislation when it comes to reducing the energy consumption of buildings. Energy efficiency is a large field of study, it doesn't mean only energy consumption minimization by improving measures applied to building envelope and its systems. An efficient use of energy and spaces is very important too. Facility Management (FM) is a field of study that considers all the aspects of a building in this regard. Main pieces of software in the field were reviewed in order to find the better software to use for space management analysis. A well known software - ARCHIBUS, that can integrate Building Information Models (BIMs) was chosen. BIMs are files containing physical and functional characteristics of the building and linked data, which can be exchanged or networked to support decision-making. Using a Romanian office building and its digital plans, a BIM has been done. For this BIM, a space allocation in agreement with organizational company structure, with functional company structure and with a Romanian standard, SR 1907-2, relate to design indoor temperature, was done in ARCHIBUS software. From all space classifications the methods of energy improvement are discussed.*

Key words: *energy efficiency, facility management, space structure, ARCHIBUS*

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1. 1. Introduction

A continued reduction of energy consumption in buildings is required by European Directives, 2010 Energy Performance of Buildings Directive [1] and 2012 Energy Efficiency Directive [2]. The building sector is the main user of energy, with a percent of 40% from Union's final energy consumption. The building energy evaluation is usually made for some design temperatures and by reporting total energy consumption to useful floor area of the building. This approach is very correct and allowed a consensus of all buildings. But the real use of energy and space in building and the people behavior inside it are at least as important as classic building energy assessment. In this regard, Facility Management (FM) is a field of study that considers all the aspects of a building.

According to International Facility Management Association (IFMA) definition, FM is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology [3]. From the definition given by EN 15221-1 [4], it can be found that FM represents "integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities." A good presentation of FM field, its history and a synthesis of new relevant FM papers can be found on European Facility Management Network (EuroFM) [5]. EU FM Coalition [6] is a European organization that emphasizes the importance of energy efficiency in FM in the context of European Directives targets. Romanian Facility Management Association (ROFMA) is an important promoter of Facility Management in our country [7].

In order to realize a building and its space analysis from FM approach the main software in the field were reviewed. FM software helps the facility managers to conduct and optimize their activities. According to an important reviews portal [8], Buildium is a finest choice of property management software, especially for residential properties and associations. It stands out for its clean and easy to navigate interface. Other recommendation is Total Management, a good commercial property management software. One of the best features is the highly customizable dashboard and its optimal multitasking capabilities. From another source of FM software classification [9], it is found DirectLine, a Web-based service that provides solutions management maintenance and inventory cost and that has 25 years of successful implementations. CAFM Explorer software is a product for organizations looking to better utilize space, improve service levels, and tighten cost control. From [9] also, ARCHIBUS software is found, it is presented as a global provider of software and services for real estate, facility, and infrastructure management. In [10] the authors realized a presentation of FM software field and it results that ARCHIBUS is one of the industry's leading software packages. The author mentions also a commercial maintenance management system, IBM - Maximo Asset Management. In [11] the authors present ARCHIBUS as a brand of internationally renowned property management software. ARCHIBUS comprises a space management tool that integrates location tracking and space management capabilities with facilities management

systems or software [12] and it allows users to link design elements, such as furniture, equipment, located in a database with CAD plans of the building [13].

Some of the facility management software, including ARCHIBUS, can integrate Building Information Models (BIMs). Building information modeling is a process involving the generation and management of digital representations of physical and functional characteristics of places. BIM helps us understand the way buildings look, the way they function, and the ways in which they are designed and built. This is a worldwide trend at the moment. BuildingSMART alliance [14] is a North American organization and a council of the National Institute of Building Science that coordinates the creation of tools and standards that allow projects to be built electronically before they are built physically using Building Information Modeling. This organization develops comprehensive norms related to BIM development as United States National CAD Standard [15] and United States National BIM Standard [16]. The FM software that use BIMs implement an IWMS (Integrated Workplace Management System) that get a single, integrated real estate-focused solution that addresses all business domains. The five core functional areas are Space Management, Operations and Maintenance, Real Estate Management, Capital Project Management, Sustainability and Energy Management. Space Management module has features that permits CAD/BIM integration. An IWMS solution is based on a single platform and database repository [17]. Other Facilities Management software use CAFM system that is defined as a combination of Computer-Aided Design (CAD) and/or relational database software with specific abilities for FM [18].

In [19] the relation between BIM and FM software is discussed. Several innovative techniques were used to input the information directly in the BIM model. For this study two FM software were used, ARCHIBUS and FacilityMAX. From [20] it can be found that ARCHIBUS Space Management is the effective way of managing space and to minimize cost wastage and optimize space usage. The optimization of space management contributes to efficiency and success to most organizations. The authors analyze space management, particularly in a Malaysian University. The importance of space management within the meaning and understanding of Facilities Management is highlighted by the authors in [21]. They recommend the best methods for space management to the higher education institutions.

From its good space analysis method and its integration capabilities ARCHIBUS software was chosen for present study.

The aim of this paper is to present a real case of interdisciplinary use of the same BIM. That means a time economy and a systematization of the data and efficient space utilization can be made. More than this, in this study, it is for the first time when a new space classification is realized in ARCHIBUS in order to allocate the design temperatures to the rooms.

2. Method

2.1. Studied building description

The building chosen for this research is named MultiGalaxy and it is rented by OMV Petrom Global Solutions SRL. The height regime of the building is 3S + P + 9E, its gross area is over 15.000 sqm and the construction year is 2008. MultiGalaxy is an A class office building, according to BOMA [22] and has a very good add on factor 3.7% (difference between the usable area and the rentable area of an office building expressed as a factor of the rentable area). The building has two generators of 700 kW power and last generation security and protection systems. It is provided with curtain walls composed of glass type Guardian and Schuco structure. The HVAC system is realized by a three pipes heating/cooling plant type Sanyo with VRF (Variable Refrigerant Flow) with ecological Freon agent. This kind of system, with three pipes presents the advantage that they can operate simultaneously in heating or cooling regime. The ability to simultaneously heat certain zones while cooling others is realized by a heat recovery system has. The input power of the system is achieved by acting the heating pumps compressors using a thermal engine with gas fuel. This kind of system can be used at nominal capacity for outdoor temperatures up to -21 degree.

Fig. 1. The studied building, MultiGalaxy, rented by OMV Petrom Global Solutions SRL

2. 2. ARCHIBUS software description

ARCHIBUS is produced by ARCHIBUS, Inc. of Boston, Mass. ARCHIBUS is a Real Estate and Facilities Management software that offers a variety of platform options to accommodate the organization's needs - from single users within a department to worldwide access via the Internet for every industry. The need to extract, duplicate, or e-mail data and files is eliminated by the new Run Anywhere architecture [23]. ARCHIBUS software is an IWMS platform that permits a workspace customization and a continuous development of the software. As any IWMS, ARCHIBUS integrates

main business domains, but in this research, Space Planning&Management domain presents interest. ARCHIBUS can operate with digital building plans and links them to its database. Thus, a lot of information and classifications related to CAD plans can be made. Any further modifications of the plans will lead to automate database modification. These kinds of space management allow a good and accurate room inventory, employee assignment to organizational space allocation, internally bill departments for their space usage and other benefits.

2.3. Spaces assignment

From the definitions related to BIM, in this paper its main definition is considered, "a model that contains characteristics of the building and linked data which can be exchanged". Thus, although, generally BIM refers to 3D models, in this paper, respecting its basic definition, a BIM is used.

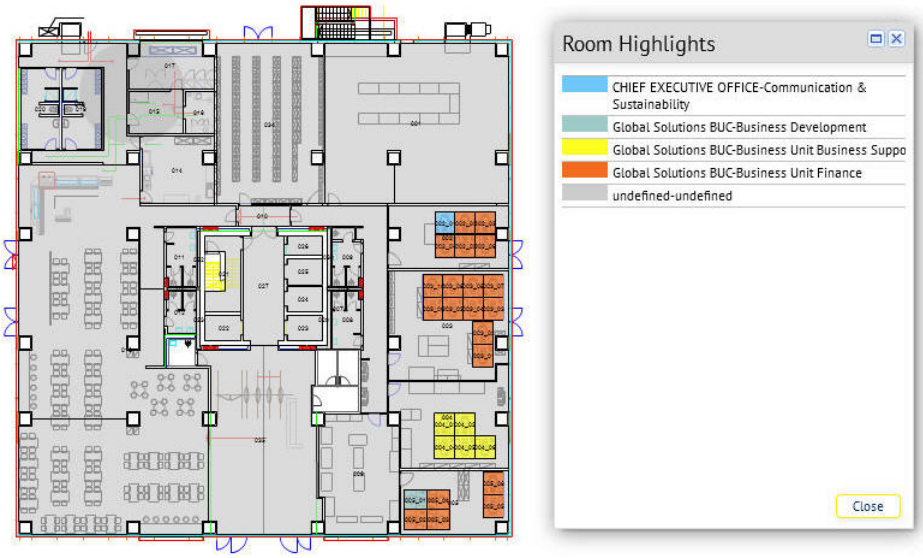

Fig. 2. MultiGalaxy building, groound floor, organizational space structure by divisions

Using ARCHIBUS Smart Client DWG Editor and the MultiGalaxy building floor plans, the rooms surfaces were linked to ARCHIBUS database. Thus, to allocate the building room's spaces to different spaces category was possible. The organizational company structure has a hierarchical model, composed of business units, divisions, departments, offices, and sub-offices. An organizational space structure by divisions can be seen in figure 2. In figure 3, functional structure of spaces according to EN 15221-6 [24] is realized. We need to mention the main international standards used in FM for area and space measurement, BOMA [22] and EN 15221-6. ARCHIBUS software is design to classify the space according to BOMA norm. But in the project where MultiGalaxy building is included, space classification is done using European norm by software customization. According to EN 15221-6 standard the room's areas are classified in primary area, circulation area, technical area, and amenity area (toilets, showers, changing rooms).

Fig. 3. MultiGalaxy building, groound floor, functional structure of spaces according to EN 15221-6

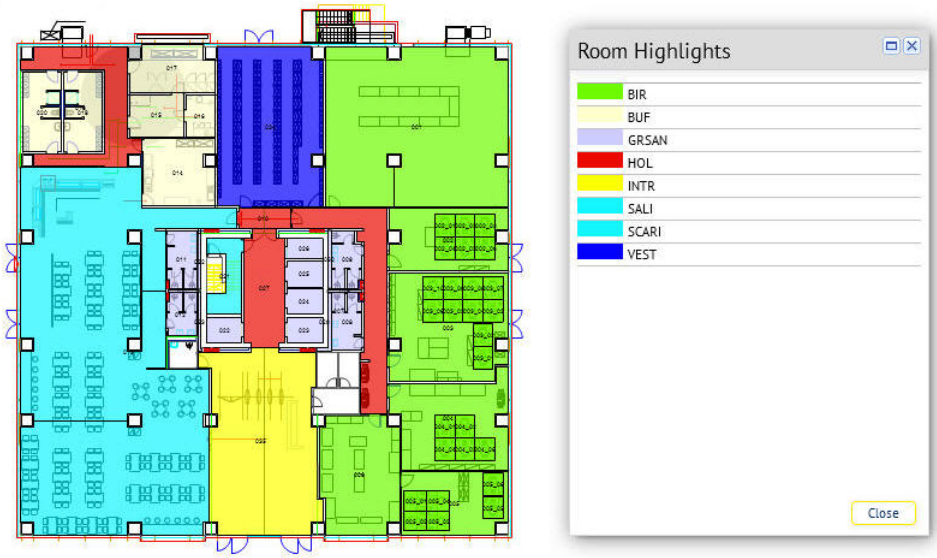

Fig. 4. MultiGalaxy building, groound floor, space structure according to SR 1907-2

In figure 4, a new space classification, according to Romanian norm SR 1907-2 [25] is made. This standard associates a conventional (design) indoor air temperature for each room's type, in residential and nonresidential buildings.

3. 3. Results and discussions

The energy consumption in buildings can be reduced by classical method that means modernization solutions of the building and its systems or by rational use of energy and spaces. By rational use of energy it is understood the compliance with comfort temperature requirements, compliance with intermittent heating or cooling program. Where possible, the change of classical comfort temperatures with adaptive comfort temperatures [26] represents a decreasing of energy consumption. And it is not least important the rational use of space that means the reduction of the space allocated to a person. Based on industry studies, many organizations, both public and private sector alike, have been found to underuse office space. And more than this, efficient and effective space usage will be controlled at an expenditure cost and level of productivity [20].

The organizational space structure by divisions can be seen in figure 2. An efficient usage of the spaces is accomplished by employee assignment to the organizational structure of the building. Thus, the energy consumption can be reported to the employee instead of sqm, and it is significantly reduced. In figure 3 a functional classification of the spaces is presented. The space use is carefully watched and the common area, for example, can be reduced and thus, the energy used, reported to sqm of rented area, can decrease.

In figure 4 a space classification according to SR 1907-2 is made; the rooms are grouped according to indoor conventional air temperatures. The room's areas corresponding to different temperatures were exported from ARCHIBUS to EXCEL as xls file. In table 1 the data is systemized and the indoor reduced temperature is computed. This temperature can be used further in energy evaluation programs in order to find energy use for the studied building. Those indoor conventional air temperatures must be the set point temperatures for the HVAC system sensors.

At the end of this paper a comparison between indoor conventional air temperatures proposed by SR 1907-2 indoor comfort temperature recommended by European standard EN 15251 [27] is made. In European standard the temperatures are classified according to comfort category (A, B and C). In EN 15251 the temperatures are structured according to type of building/space and they are not at the same detail level as is SR 1907-2. As can be noticed in Table 1 the mean comfort temperature (for category B) is of 20 ºC in EN 15252 case and the mean reduced (design) temperature is of 18.4 ºC in the case of SR 1907-2.

Table 1

Indoor reduced temperature computation for MultiGalaxy building, ground floor

	BIR	HOL	GRSAN	BUF	INTR	SALI	SCARI	VEST		
Supr [m^2]	519.1	54.4	84.3	115.6	123.5	376.0	12.2	105.8	1390.9	TOTAL
T_i (SR 1907-2)[ºC]	20	15	15	20	12	18	15	22	18.4	T_i_red
T_i (EN 15251)[ºC]	20	20	20	20	20	20	20	20	20.0	T_i_comf

5. Conclusions

In conclusion, space management is one of the essential components in FM and in building energy efficiency.
In this paper it is for the first time when, in ARCHIBUS software, such an interdisciplinary space classification is made, all of these classifications are related to energy efficiency in the building. In the project that includes MultyGalaxy building, the possibility of space classification according to European norm EN 15221-6 was made by software customization. A new space classification, accordingly to SR 1907-2 is realized. It can be used in further computations for building energy assessment and for the centralization of room's set point temperatures used by the HVAC system.
For the studied building, a comparison between the indoor conventional air temperatures recommended by Romanian norm and indoor comfort temperatures proposed by European standard was made. A significant difference, of 1.6 ºC can be noticed. Although the EN 15251comfort temperatures are partially transposed in Romanian norm I5 [28] we recommend to update indoor conventional air temperatures proposed by Romanian norm SR 1907 according to our day room types. The indoor air temperature is different from comfort operative temperature and also it is important in design and HVAC set point.

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