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How to use Building Information Systems for a transition towards Sustainable Building Operation

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Abstract
BIM Building Information Model or Modelling connects many different information systems from various actors during the building construction process with each other in one easily accessible and understandable model. BIM assures an effective and efficient building construction process by reducing failing cost and reduces the use of materials by so called clash-controls. More and more buildings and infrastructural works are completed with help of BIM and materials, energy, time and money are saved by doing so. But why not use BIM for the exploitation phase of both new and existing buildings? By connecting the BIM model with the other exploitation information systems as Facility Management Information Systems (FMIS), and Building Information Systems it's possible to create an easily accessible and understandable building and operating information management tool. Furthermore using BIM during the exploitation will increase the BIM market.
This paper makes clear that BIM an make a big difference in the quality of the exploitation and operation of buildings, by helping creating a better and comfortable indoor climate while reducing energy losses and costs. Facility Managers should be the owners of this "exploitation and operation BIM" and have to know which information they must extract from the BIM and how to manage this information system. Another benefit will be time savings, and thereby money savings, because searching, reconstruction and updating building information again and again is not needed anymore. The paper also discuss some of the problems with the implementation and use of such a BIM.

Keywords - Facility Management, Building Information Management Systems, Sustainable Management and Maintenance, Sustainable Operation of Building.

1. Introduction

Many facility organizations are falling short in achieving a good indoor air quality and a low energy use in their buildings. Both appear not to meet user expectations and design specifications [7]. The indoor climate is even the biggest source of complaints of all facility services and energy shows up

to be 30% too high for what might have been expected [18]. The result is a lot of unnecessary costs related to complaints handling, unnecessary adjustments to equipment, excess of energy consumption and a reduction in turnover of an organization by a loss of performance up to 15%. A study found that facility managers have insufficient control over these matters because they were not involved in the design of the building and its facilities. Also there is insufficient knowledge available of installations and their impact on end users and there is insufficient cooperation between facility managers and technical management [16]. This is because many facility managers do not have sufficient technical knowledge and information and therefore the responsibility of the indoor climate is too often delegated to the technical building manager, who doesn't have the required knowledge on customer information and user preferences. External technical building managers also have another (own) interests. Thus, the advantages of an optimal technique and management are not achieved. It is therefore urgent that organizations are been committed to a building information management system with good collaboration agreements for all who play a role in the construction, renovation and operation process of the building and in the management of the indoor environment and customer satisfaction. [6], [7]. Following the study of Joosstens [7], further research has been done on what information means the parties have at their disposal for an effective and efficient building operation. The paper furthermore studies how they have to use this information and how they would like to use it, what the developments on the information management are and what possibilities there are for a more effective use of these resources in order to achieve a better quality of operation of the building and its installations. The focus of this paper lies in the existing (office) buildings.

2. Methodology

Together with students of The Hague University a study, reported in several Dutch reports we refer to in the core of the paper, was carried out among Facility Managers, Building Managers, Technical Managers, Suppliers and Users of medium to large office buildings of forty organizations from the sectors of Government, Business Services, Healthcare and Education in the Netherlands. The study was carried out by using desk research, interviews and surveys. The Facility Managers, Building Managers and Suppliers of installations and information systems were asked about the usability of Building Management Systems (BMS), Energy Management systems (EMS) and Facility Management Information Systems (FMIS) as a management information and control source and about the degree of satisfaction about the systems for the management of the indoor climate and the energy use of the installations. In addition questions were asked about the level of cooperation between the Facility Managers and Technical Services regarding the control of the indoor climate and the energy use. There were

also questions about the extent of and satisfaction with the communication between the Front Office, the Back Office and the communication with the end-users of the organizations. The results of the desk research and the interviews are presented first for the different management systems, and then for their possible combinations.

3. Results

First relevant information about the different management systems is briefly described and presented.

3.1 Building Management Systems (BMS)

A building management system is a computer based control system that is used by managers of a building and its purpose is to create an optimal working environment for the user to detect early stage errors in the systems, identification of errors in the system, report unusual patterns in energy use and effective approach to generate energy targets' [3]. A BMS (e.g. Priva, Honeywell, Siemens, Cofely) has two main objectives: the automation of processes and the provision of information about the way it works. Information on energy consumption is a component that can be added in the BMS if required. The information on energy consumption can be then converted by, for example, a Facility Manager into useful management information. From the interviews a shift was observed from the BMS being used only by the technical service to a use across the organization such as the purchasing department. The information on energy can for instance contribute to the preparation and management of performance contracts. Therefore there are packages within a BMS available for different user groups. [15]

The building management system, however, is not optimally used by all actors to control on the quality and energy consumption of the installations. The BMS is rarely used as a monitoring system and, as a result, the information that could be used to analyze the underlying causes of comfort and energy problems is not used. Additionally, the BMS is not linked to the Facility Management Information System (FMIS, see &3.3) in which comfort complains are generally recorded.

The interviews reveal that a number of general improvements can be made to the BMS. From the interviews it appears that there are different opinions and wishes about what should be implemented in a BMS. Therefore a BMS should be adjustable per organization in order to respond to the various needs. A possibility could be to add different modules that covers the organization's needs. It is also often suggested to integrate the FMIS and the BMS because these systems have some similar features. It would also be good if the BMS could be accessed from anywhere. Currently, there is often only access to from PC's in a technical room. The interviews revealed that it would be better if the BMS was available in a network you can log in from

everywhere. In that case the BMS is not linked to a PC, which is usual at the moment, but to an account.

Facility Managers prefer to receive notifications from these systems within a single channel. Also they prefer not to receive too many notifications at once and there is a wish for a hierarchy. Especially acute disturbances have to come in, but the users do not want endless reports over temperature fluctuations and such complaints. Above all the building manager must be able to access the data whenever needed. It is also important that the facility management department are involved in the implementation of the BMS from the beginning. [9]

3.2 Energy Management Systems (EMS)

"Energy management is to perform on structural and economical ways organizational, technical and behavioral measures to minimize the use of energy, including the energy for the production and use of raw materials and consumables" [1]. This definition of energy management systems indicates that the purpose is to get energy consumption as low as possible. This is possible by taking organizational, technical and behavioral measures. Organizational measures are agreements on roles and responsibilities, and procedures, processes and facilities to carry out energy management. The adaptations to technical installations through the building management or maintenance of the installations themselves are technical measures. For example, a technical measure is the monitoring and recording of power consumption. Behavioral measures concerns for example the behavior of the end user in the building. It is expected that with an integrated approach with regard to the procurement of energy, functioning of the systems and indoor climate, organizations can save fifteen percent on their energy costs. [9]

Energy management systems (e.g. eSight, Wattics, ePortal) already use a variety of techniques. The problems with traditional energy management models is their user-unfriendliness and the fact that they are too static to adapt to changes that take place often in organizations, like internal moves. [2] In an energy management system other overviews can be generated than in a BMS. Sometimes energy management systems used a BMS to get information about the power consumption, for commissioning purposes or to couple it with the opening times of a building. [9]

One of the reasons organizations don't use the possibilities of EMS is that the current generation of Facility Managers are not trained in energy management, it is in fact still a relatively new field of expertise.

Organizations are sometimes not well aware of their power consumption, making it impossible to manage energy use in order to obtain an energy consumption as low as possible. During this research the focus was on the operational phase but interviewees indicated a number of times that the Facility Manager is not involved in an early stage in the design and construction process and that it results in high costs afterwards because the

building must be modified after the construction phase to make good energy management possible. Benchmarking with other similar organizations is desirable but often difficult to achieve in a fair way, because all buildings operate under different circumstances. When buildings are rented, energy management appears to be very inconsistent, such as heating and cooling at the same time in the same building section, because the set-points in the central system do not match the set-points of the local system (the rented part). Also landlords are often unwilling to invest in energy management measures because of the split incentives. Current developments, such as the intensive use of 'smart' mobile phones, are not often used in energy management. The smartphones can be used by end users for reporting complaints and operating the lighting and the indoor climate, but also to inspect their own energy consumption. This may encourage sustainable behavior tremendously. [15]

3.3 Facility Management Informatie Systeem (FMIS)

A Facility Management Information System can be described as: "*an integrated man-machine system that provides information on delivered and available facilities which serve to support the operational activities, management, analysis and decision-making functions within the facility organization by which business processes and workflows are structured, managed and automated*." [8]. FMIS (e.g. Planon, TopDesk, Axxerion, Ultimo) is a support system where, for example, complaints about the indoor climate can be submitted. End users can submit reports according the CDIF principle (Complaint, Desire, Information request, or Failure). This can be done through an app on the smartphone or PC, or through self-service solutions on the internal network. These complaints come in at the front office and, depending on the standards of the organization, they are directly send to the back office, for example to the Technical Department or to the relevant supplier. The whole process is monitored by the system as well, including the number of complaints about indoor air quality over a given period, the number of complaints that are still open, or are handled, the costs that were involved in the handling and whether all this satisfies the prescribed service levels. Facility Managers make their analysis with help of this information. Doing so, it’s possible to determine which installations or areas often have complaints and choices are made with this information for long-term maintenance or for prioritization of work.

The technical aspects of indoor climate is also supported within the FMIS, this has to do with maintenance on indoor climate systems and with the mechanical engineering and electrical infrastructure. In this way the FMIS "maintenance management" is not only reactive (treatment of symptoms), but can help to plan actively preventive maintenance for a good indoor climate. The Facility Manager then also knows how much money he should set aside to maintain the indoor climate at a desired level.

Interviewees also regularly mentioned that FMIS shows some shortcomings. In particular, the ease of use to enter complaints about the indoor climate is not considered user-friendly. The part of energy management is not widely used yet, partly because the facility manager does not know what the possibilities are. Complaints are often not sent directly to the suppliers. This is generally for two reasons. First, not all facility managers want that, because of the cost implications. They want first to make a decision if something should be done. Furthermore the FMIS provides insufficient support to forward the complaint automatically. Additionally it is at present practically not possible to report complaints through an app or by means of a photograph. It is also reported that in order to get reports from the system, a lot of unnecessary actions are required. Often there is no linkage of FMIS with other information systems because the systems do not operate with open standards. [15]

3.4 Building Information Management (BIM)

BIM is according to the Governmental Real Estate Organization in the Netherlands a "*digital three-dimensional building model linked to databases with all data for the development, design, construction and management process, for all actors working in that process*" [11] . BIM (e.g. ArchiCad, Revit, VectorWorks) is an abbreviation of Building Information Model, or Building Information Modeling or Building Information Management. This paper is about the management process during the operation of a building and therefore we opted for Building Information *Management*.

BIM is often used in a PPP construction (public private partnership). A common form is that of the DBFMO contract. DBFMO is an abbreviation for Design, Build, Finance, Maintain and Operate. In a DBFMO contract market parties or a consortium are not only responsible for the financing, design and construction of an object, but also for the maintenance of the building and the supply of services for a specified period. [17]

It appears that BIM is not yet used in the exploitation phase of buildings. Nowadays very few parties think about the exploitation phase yet. Building companies provides a BIM model packed with information which often is "thrown away" after completion of the building. In particular, this is because there is information available for design (specifications) and performance but not for the operation of the buildings. This while the value of BIM should be precisely the information that can be used in the operation phase. According to the Dutch Building Information Council "*BIM should not stop with the operation phase; but would just have to start there*." and "*BIM is not a new idea but a fact and it will only become more important to be able to speak that language*." BIM is of added value for al stakeholders in the building environment. [5]

The added value of BIM during the operation phase should be that all relevant building information can be found in one single visual model,

whereby it is possible to add or to extract information out or into the model. Now, this information is often stored in paper form in different drawers and cabinets where it is difficult to find. In one and the same organization several employees manage this information, but do not share it, and often this information proves not to be up-to-date. If revisions, contract modifications, fault history, tracking of changes in the control strategies are passed on to the key stakeholders is not clear, and it is not known whether the information that is used in the exploitation process of the building is reliable. The interviews shows that for all the reliability of the information and the speed of retrieving is very important. [17]

The different studies that have been done about BIM in the exploitation and operation phase, unanimously reveal that BIM has an important role to play in Facility Management and it is estimated that using BIM in the operation phase of a building could save up to 20% in operating costs ([4], [12], [13], [14], [17]).

This savings are mainly accomplished by the reduction of search time of documents needed for the efficient maintenance of the building. The investments needed to link a BIM model to other information systems, tot update all relevant information, to digitize all relevant building information and add this into the system, including the building construction drawings and plans to merge in a 3D model, could be paid back within two years. Dutch experts (see above mentioned studies) see these savings as added value to the primary process even more than as cash savings on cash flows. BIM will therefore not directly result in fewer employees, but rather to work more effectively so that more focus can be placed on adding value to the primary process. [13].

Most facility managers, who have not been involved to take part in the construction of their building, are now having the responsibility for the management of this building. However, they do not have the knowledge needed to operate the exploitation BIM and to communicate with BIM partners. Furthermore the BIM systems from the design and construction phase are not connected to the FMIS systems of the facility manager. Finally, "*a complete BIM model implementation during the operational phase seems too costly and too complex*." [4] But is that really so?

4. Towards a good link between different information systems

It has been noted that actors make insufficient use of existing information on the building, the building installations, the energy consumption, building and space use, the indoor comfort complaints and how to handle them. Besides the lack of control and knowledge of the technical management, it appears that the facility managers have insufficient access to up-to-date information about the building and its installations. The building plans and construction drawings are often outdated and not accessible, information on installations such as warranty, technical

specifications, settings, maintenance state, etc. is incomplete, outdated and often difficult to find. This not only costs the Facility Manager up to 30% of his working time, also other involved parties experience this loss of time [12].

The current information systems work next to each other and not together, these systems are therefore not integrally used and managed. According to several experts there will always be different information and management systems being used and that should also be kept so. In practice, the organization will have to decide which information is managed in witch system. Important basic principle is this is: "*it does not matter where the information is managed, as long as it is been managed*" [13]

Experts says that in future BIM will be increasingly seen as a network of linked open databases with different building information (Open BIM). The exchange of information can take place on the basis of specifications according to the Construction Operations Building Information Exchange (Cobie) protocol for the provision of information needed by facility managers throughout the life cycle of a building. BIM will then be used as a management tool that may lead to an improvement of the operational phase. According to the BIM experts, there is one thing certain: *to get information whatsoever from which information system, it must first be stored into it.* The ideal picture is that all information of the building is stored into a large database where the information could be retrieved at any time and can be modified if necessary. How existing information systems could be combined into a useful Integrated Building Information Management System (IBIMS) is outlined below.

However, the set up of such a database is time consuming and it seems more logic to start by using and linking the existing systems and databases. Having confidence in the quality of the available information is also very important.

BIM have to be tailor made for the exploitation phase, this means that, before starting with BIM one have first to look at what one wants to accomplish with BIM and what is going to be deployed. BIM experts are warning for the extreme amount of opportunities of BIM. According to them, one must decide which purposes are proper for the organization. [13]

In the design of an advanced building-information management system it is crucial to determine the communication structure. This structure is based on the principle: the right information in the right place, available at the right time, in the proper transfer form, for the right person. By determining in advance how communication should be arranged, future misunderstandings and irritations can be avoided. Parties know exactly what they can expect from each other, when and how. By establishing the communication structure in a communication plan all parties will be obliged to comply to it. [10]

A well-arranged FMIS possesses a lot of information the BIM database can be filled with. According to the BIM experts, FMIS is a good stepping stone towards a full BIM database. FMIS and other management systems have therefore to find a way to the open BIM idea. All studies clearly show that the desired outcome can only be achieved if the various systems can actually communicate with each other, making possible to link BMS, FMIS, EMS, BIM and even the financial and personnel management system (e.g. SAP) and the necessary collaboration software (Cobie). Of course in addition to the newly designed integral information system, its essential that cooperative agreements between all involved parties are made.

5. Conclusions and recommendations

In the short term the full implementation and operation of a exploitation BIM by Facility Management is a (too) big step that seems not feasible for many organizations. Our study shows that the phased introduction of (parts of) BIM however is estimated by the experts to be possible during the operation phase.

For existing buildings, it is important that a IBIMS is introduced in small increments. Existing building information will be digitized and should be linked to existing information systems. It is important that there is first an input protocol outlining the aims of the system, clear descriptions of unambiguous procedures and clear descriptions of the roles and responsibilities of the different stakeholders. One can begin to couple the relevant information from the BMS about the energy consumption and the indoor comfort to the user information from the FMIS in order to analyze, decide and manage. Then coupling with a separate energy management system could be realized to take even greater advantage of managing in more detail on the energy consumption in connection with the indoor comfort. Finally, a 3D up-to-date drawings file can be linked to the system to create for each of the involved actors an easily accessible IBIMS, making it possible to visualize bottlenecks in the power consumption, building management and indoor comfort and to react adequately. It is important that, through small successes in the short term, gains are achieved, thereby creating a foundation for the ultimate goal: optimally manage the building on a sustainable way.

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