Revista Romana de Inginerie Civila, Volumul 9 (2018), Numarul 3

Economic and energy efficiency of investments in digitalized systems

Gabriela Mehedintu[1], Nicolae Postavaru[2]

Universitatea Tehnica de Constructii Bucuresti
Bd. Lacul Tei nr. 122 – 124, cod 020396, sector 2, Bucuresti, Romania
E-mail: gabriela.mehedintu06@gmail.com

Abstract. *The nowadays digital boom is a driver for the strategies of the companies that want to remain long-term efficient. Investments in technological solutions, especially in the facility management field, have a positive impact on the evolution of a company. This paper will show through a practical example, how it is taken a decision in terms of a technological investment in the facility management field and which the long-term economic benefits are.*

Key words: digitalization, facility management, BMS, investment

1. Introduction

Facility management is focused on the supportive services of the construction sector. At the same time, it is the main responsible sector for over 80% of the total life-cycle costs of a building and it influences 100% the utility consumptions. Therefore, in an era of digitalization, investments in technology software are essential for economic and energy efficiency and represent a priority for facility managers' strategies of optimization and adaptation to the new and to develop the investment into a successful business model for the company.

2. Digitalization in facility management

Facility management is the second most important field in company, regarding costs and economic impact on short-term and long-term perspective. It is a must for the companies to follow the trend of digitalization and to adapt to new challenges, in order to be a competitive company.

To achieve long-term benefits, managers within a company, especially in the construction sector, must make decisions by having in mind that facility management is a business in the life-cycle of an investment and that it can develop this investment into a business with revenues. Facility management is an expense spread over many years which highlights the construction business, brings added value to the building, by creating technical and economic efficiency for the company. This added value is reflected over time in an estimated and gained profit. If the company doesn't focus on facility management and if it doesn't take advantage of technological progress, the estimated profit could be lost over time.

2.1. Benefits of digitization in facility management

"To be digital" is no longer a characteristic of tech companies and a market trend, but a day to day necessity and an enabler, especially in the facility management sector which, according to Frost & Sullivan's market research report, will be worth nearly $1 trillion by 2025. [1] A global study of MIT Sloan Management Review and Deloitte shows that over 90% of the respondents anticipated in 2015 that digitalization will be soon integrated part of our lives and of each industry, as we already rely on technology each day. [2]

Digital technologies have radically changed the way of working, the workplace itself and the way buildings and facilities are being used. With permanent internet connectivity and cloud services, facility management employees can work from anywhere and monitor and control the integrated system of a building, from the personal computer, tablet or smartphone. At the same time, these technologies provide complex information and database on activities and systems performance on which facility managers can make data-driven decisions about the use of space, equipment and installations, activities, resources and capital planning.

From this point of view, it is crucial for facility managers to adapt to the digital world, in order to provide additional services for the building occupants, including to meet their needs in terms of workplace conditions, but also to be more efficient in terms of costs and environmental impact. Therefore, facility managers have to take over their strategic role and invest in new technologies that improve services, reduce costs and sustain business models. [3]

The digitization of the facility management function is playing out across four dimensions [4]:

- Digitally-enabled FM services;
- Employee productivity and retention;
- Energy and sustainability management;
- Compliance.

The digitalization of the processes has to be implemented and used by people to get higher productivity, better energy efficiency and better economic results, with the existing resources.

2.2. The need of digitization in facility management

Although the digital world is part of our lives, there still exists companies and buildings that are inefficient. In these cases, facility managers are managing heft energy bills, lacking maintenance processes, dissatisfaction of the building's occupants. Now, in these times, it is the proper moment for them to adapt and to invest in technologies that can provide a better alternative to the status quo of the inefficient buildings. They can convert to more intelligent buildings, by just adopting the digitalization. [5]

Many studies show that technology used in facility management can reduce costs and be more efficient and effective, whether we speak about automating monitor of workplace environments such as temperature or humidity, or about the improved productivity of the facility management employees by digitizing paper-based processes. A SWG survey shows that nowadays, 72% of the survey respondents (facility managers) are using technology to improve the management of staff and contractors to minor equipment and allow pre-emptive maintenance, up 27% from 2015. Still, about one-third of the companies are using Excel spreadsheets and about 15% are using paper-based checklists to manage facility management activities. [6] This shows that there is potential for growth and optimization in terms of the degree of use of facility management technology.

2.3. Investment in BMS (Building management system), a first step into the digital world

Based on the previous and numerous other studies on the impact of technology on facility management, one basic solution for the non-tech companies to transform into more efficient ones is the investment in a BMS (building management system).

BMS is a controlled system that can monitor, integrate and control data from all equipment (electrical installations, HVAC, access control – for traffic monitoring, fire alarm systems - advantageous for emergency cases, etc.) in a building, in two directions: it takes signals from the field equipment and sends remote commands. [7] The digital devices such as sensors, controllers, communication gateways acquire, analyses and send data through the system and the user obtains actionable information. [8]

The interconnected data is providing information for the facility manager about [9]:

- Building status and construction contracts;
- Space management;
- Equipment characteristics, history, needs, location, maintenance necessities;
- Working environment;
- Building occupants: performance, working time;
- Resource usage;
- Life-cycle scenarios, etc.

An essential part of building management is energy management. It aims to minimize energy consumption, related emissions and energy costs. Energy management applied to the building management includes:

- Optimization of industrial installations and their operation;
- Optimizing physical influences on energy consumption;
- Optimizing power supply.

Important for the energy management is the comprehensive control of consumption and costs. By systematic analysis of energy and water, costs savings potential is identified and improvement measures are implemented if necessary.

Consumer savings and costs generated by energy management could have been stabilized in recent years, using business management tools and modern and transparent IT support. Also, the reduction of energy consumption contributes to meeting the requirements for improving climate protection.

3. Evaluation of economic efficiency of investment in BMS

Facility management investments in modern technology are an intelligent strategy for optimization and efficiency, due to their positive long-term impact on the company.

In the context of sustainable visions, the investment decision must be based on rigorous criteria that have the greatest benefits (maximum outcomes) under the conditions of minimum economic efforts. Only in this way, the activity can work effectively.

The evaluation of investment projects follows the costs and revenues realized with impact on the company's overall financial situation and also on the national economy, as they have a long-term impact and uncertainty, which is why the evaluation must include the assumed risk. Only when the company's activity exceeds the loss level is considered effective and has an optimal outcome.

Therefore, in order to identify correctly the economic value of the investment, it is necessary to analyze the efficiency indicators. The economic analysis of investments involves knowledge of hardly quantifiable components or interrelated and targeting a system of values to be considered. Hence the wide variety of indicators and their particular character. They try to express the content of the various economic characteristics and give the decision maker information about the economic system at that time.

4. Case study – Investment in BMS for an office building

4.1. Description of the Building Current State

A service company operates in an old office building in Bucharest, built in 1968-1973. It has one basement and 5 floors, a total area of 2.615,14 m^2 and a usable area of 2.315,74 m^2, where 163 employees work 40 hours per week. It is structured as it follows:

- 1 reception;
- 6 lobbies;
- 31 offices;
- 10 toilets;

- 7 storage room.

It has the following technical equipment:

- 1 elevator;
- Electrical lighting equipment;
- Low voltage electrical installations;
- Gas central heating;
- Radio burglar alarm system with 90 detectors;
- 40 air conditioning devices – 12.000 BTU;
- Water supply system and sewage.

The consumptions and costs of the utility for the years 2015 and 2016 are presented in the following table together with their graphic representation:

Year	Month	Gas			Electricity			Water		
		Total cost (Lei)	Lei/MWh	Consumption (MWh)	Total cost (Lei)	Lei/MWh	Consumption (MWh)	Total cost (Lei)	Lei/m^3	Consumption (m^3)
2015	January	21.640,08	112,39	192,54	4.200,32	46,85	89,65	844,27	3,68	229,42
	February	25.674,35		228,44	7.030,16		150,06	832,58		226,24
	March	23.245,75		206,83	10.416,61		222,34	1.115,56		303,14
	April	17.584,76		156,46	1.157,66		24,71	722,66		196,38
	May	22.994,19		204,59	1.043,06		22,26	919,11		249,76
	June	2.663,79		23,70	1.861,61		39,74	951,85		258,66
	July	7.210,24		64,15	2.600,65		55,51	1.239,52		336,83
	August	1.354,11		12,05	610,40		13,03	1.059,44		287,89
	September	2.104,84		18,73	1.921,25		41,01	1.047,74		284,71
	October	7.105,00		63,22	2.666,13		56,91	743,71		202,10
	November	10.839,92		96,45	1.206,77		25,76	986,94		268,19
	December	20.613,39		183,41	3.405,16		72,68	902,74		245,31
	Total	**163.030,43**		**1.450,58**	**38.119,80**		**813,66**	**11.366,13**		**3.088,62**
2016	January	23.326,29	130,00	207,55	2.694,19	42,36	63,60	1.134,27	3,72	304,91
	February	16.148,79		143,69	406,94		9,61	977,58		262,79
	March	18.145,45		161,45	2.691,85		63,55	760,08		204,32
	April	23.370,73		207,94	1.033,71		24,40	2.759,68		741,85
	May	21.637,74		192,52	1.330,73		31,41	1.370,48		368,41
	June	13.138,87		116,90	4.822,42		113,84	839,60		225,70
	July	12.130,89		107,94	2.970,16		70,12	2.013,63		541,30
	August	1.941,13		17,27	5.051,61		119,25	1.199,76		322,52
	September	376,53		3,35	970,56		22,91	1.075,81		289,20
	October	5.743,87		51,11	3.456,61		81,60	1.728,31		464,60
	November	5.996,45		53,35	4.876,21		115,11	1.234,84		331,95
	December	19.030,08		169,32	3.021,61		71,33	1.276,94		343,26
	Total	**160.986,82**		**1.432,39**	**33.326,61**		**786,75**	**16.370,97**		**4.400,80**

Fig. 1. Consumptions and costs of the utility for the years 2015 and 2016.

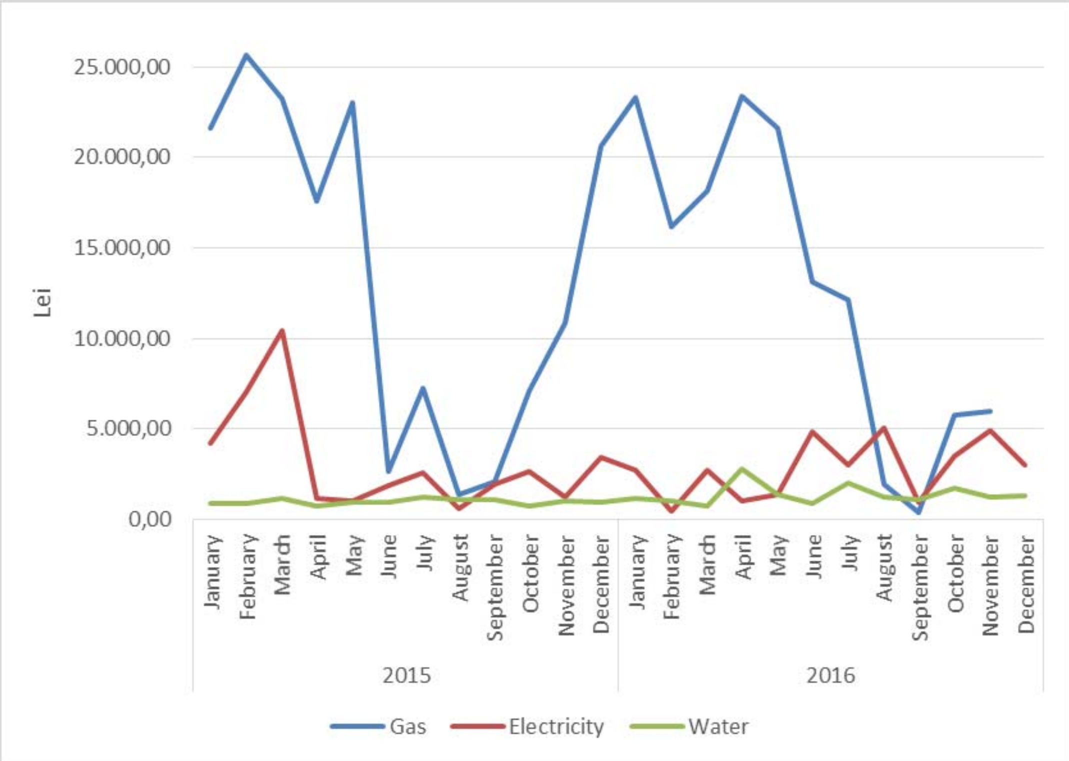

Fig. 2. Costs of the utility for the years 2015 and 2016.

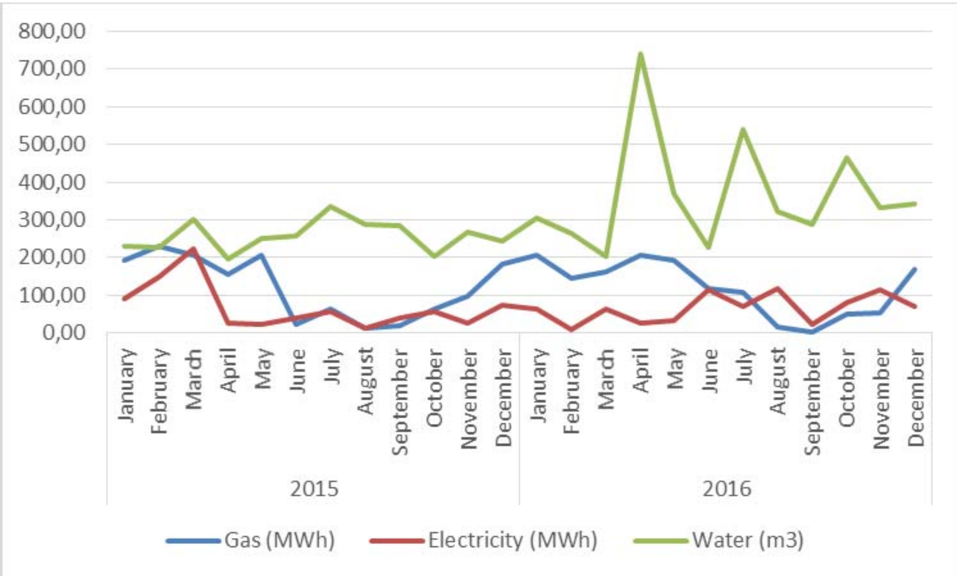

Fig. 3: Consumptions of the utility for the years 2015 and 2016.

4.2. Presentation of the investment alternatives

After a market research and an analysis of the best in class alternatives, the facility manager of the building has chosen two personalized offers, with similar technical properties:

- Offer 1: 638.015,00 lei VAT excluded;
- Offer 2: 655.110,00 lei, VAT excluded;

Both offers of BMS includes following systems:

- Fire protection system;
- Security system;
- Integrated HVAC system;
- Lighting system with sensors;
- Water system with sensors;
- Site controllers;
- Field equipment;
- Integrated software.

4.3. Assessment of the investment economic efficiency by calculating the economic indicators

In order to decide upon the best alternative for the building, in economic terms, we will calculate some efficiency indicators:

a) Investment value/volume of the invested capital – the total economic effort made for the investment, in order to achieve the objective:

$$I_t = I_d + I_{col} + I_{con} + C_s \qquad (1)$$

Where:
I_t = total investment
I_d = direct investment (reflected through the general estimate)
I_{col} = collateral investment (access roads, ensuring the power supply etc.)
I_{con} = related investment (expenses regarding the initial equipment, additional expenditure)
C_s = additional investment expenditure (design, preparing the human resources necessary for the new objective, etc.)

b) Investment performance term: until the commissioning, the financial resources are blocked. It is measured starting from the signature date of the contract. A commissioning before the scheduled term means an economic advantage.
c) Operation time of asset: starts upon its commissioning, should be as long as possible, under the conditions of a proper functioning.
d) Investment payback period: indicator with a strong impact on the investment decision because it offers information about the period in which the invested capital is recouped from the economic results of the asset performance.

For assets to be modernized:

$$D = \frac{I_m}{P_{hm} - P_{h0}} \qquad (2)$$

Where:
D = payback period

I_m = value of the capital invested in modernization

P_{hm} = annual profit got after modernization

P_{h0} = annual profit got before modernization – it will be recouped from the extra profit obtained as a result of the investment

In order to estimate the payback period time and to calculate the economic return on investment, it is considered an operation period of 15 years, an increase of the profit as presented in the following table and a constant annual net profit growth of 4% beginning with the year 2020.

Year	Net annual profit (lei)	
2015	2.241.060,59	
2016	2.297.087,10	↗2,5%
2017*	2.370.593,40	↗3,2%
2018*	2.656.817,60	↗3,5%
2019*	2.749.806,22	↗3,5%
2020*	2.859.797,30	↗4%
*estimated		

Fig. 4. Estimated annual net profit.

e) Economic efficiency coefficient: is the reverse of the payback period.

f) Economic return on the investment: the most comprehensive indicator because it takes into consideration the whole investment process. Simply explained, the indicator shows how many lei can be obtained as profit from each lei unit invested:

$$R = \frac{P_t - I}{I} = \frac{P_h \times D}{I} - 1 \qquad (3)$$

Where:

P_t = total annual profit

P_h = net annual profit got after having recouped the investment, until the end of the operation time

I = total volume of investment

D = operation time

g) Investment payback speed: gives information about how many times the invested capital can be recouped during the operation time.

According to the calculations and the analysis of the indicators of the investment economic efficiency, it is obvious to decide upon investment 1 in BMS, as the best solution for the given building. The green marked results are the proof of this.

Indicator name	Investment 1	Investment 2
Investment value	645.345,00	662.440,00
Completion time	11 months	8 months
Operation time	15-20 years	15-20 years
- Site controllers	15-20 years	15-20 years
- Land equipments	15-20 years	15-20 years
- BMS Software (+updates)	3-5 years	3-5 years
Payback period	2.25 years	2.32 years
Economic efficiency coefficient	0,44	0,43
Economic return	5,71	5,53
Payback speed	6,66	6,46

Fig. 5. Investment economic efficiency.

But, it is not enough to take into consideration only these indicators, when deciding upon an investment. It is also necessary to take a look at the economic advantages given by the consumptions after implementing the new system.

4.4. Estimating the consumptions after investments

The future consumptions of the utility for the next three years can be estimated based on the technical specifications of the equipment and n the experience and data provided by the two BMS suppliers:

- Alternative 1: In the year 2017, the consumption is growing, because it is the year of the investment implementation. After that, it is expected a total decrease for all utility, as a result of the BMS: 30,67% for gas and 4,67% for water. The highest reduction should be in electricity, 65,86%, due to the new efficient equipment, as described in the following two figures:

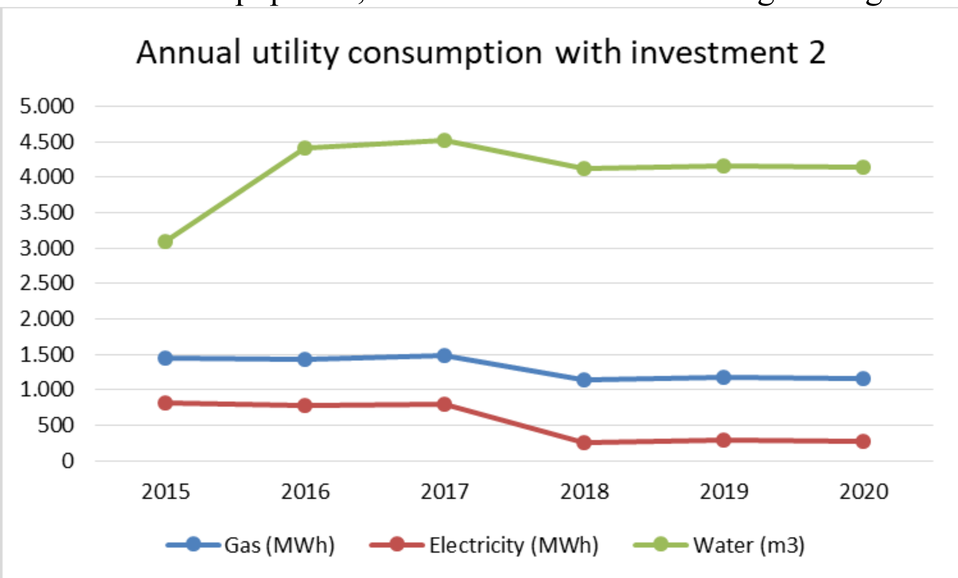

Fig. 5. Estimated evolution of annual utility consumption with investment 1.

Investment 1	Gas (MWh)		Electricity (MWh)		Water (m3)	
2015	1.450,58		813,66		3.088,62	
2016	1.432,39		786,75		4.400,80	
2017	1.488,40		801,02		4.510,22	
2018	1.142,50	↓ 23,40%	256,89	↓ 67,93%	4.117,83	↓ 8,70%
2019	1.172,86	↓ 21.20%	292,85	↓ 63,44%	4.154,36	↓ 7,89%
2020	1.156,93	↓ 22,27%	270,66	↓ 66,21%	4.144,89	↓ 8,10%
Total ↓32,13%		**↓ 22,29%**		**↓ 65,86%**		**↓ 8,23%**

Fig. 6. Estimated annual utility consumption with investment 1.

- Alternative 2: As in the first case, in 2017 the consumption is expected to grow due to the implementation period of the BMS. After the implementation, following decreases in utility consumptions are expected: 31.56% for gas, 71,69% for electricity and 4,80% for water, as described in the following two Figures:

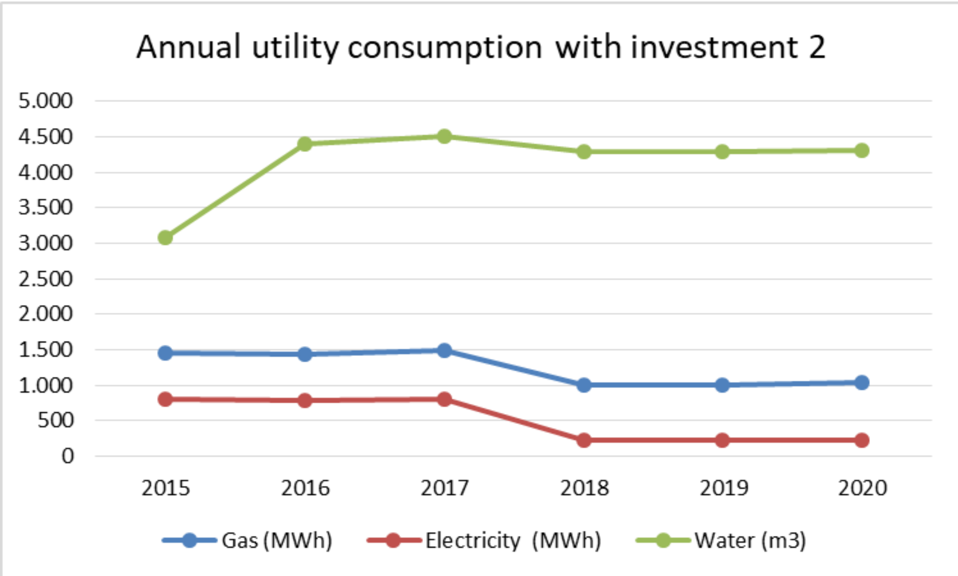

Fig. 7. Estimated evolution of annual utility consumption with investment 2

Investment 2	Gas (MWh)		Electricity (MWh)		Water (m3)	
2014	1.450,58		813,66		3.088,62	
2015	1.432,39		786,75		4.400,80	
2016	1.488,40		801,02		4.510,22	
2017	1.006,16	↓ 32,40%	222,60	↓ 72,21%	4.289,22	↓ 4,90%
2018	1.010,47	↓ 32,11%	233,58	↓ 70,84%	4.289,22	↓ 4,90%
2019	1.039,35	↓ 30,17%	224,13	↓ 72,02%	4.302,75	↓ 4,60%
Total ↓36,02%		**↓ 31,56%**		**↓ 71,69%**		**↓ 4,80%**

Fig. 8. Estimated annual utility consumption with investment 2.

4.5. Investing in BMS Final Outcomes

The above analysis shows that the most consumption savings are coming from the electricity, as it is the resources used by all equipment of the building. The improvements as a whole are about 80% due to the efficiency of the heating and cooling system and the rest due to the lighting system. [10]

When analyzing only the economic effect of the investment in BMS for the office building, it is very clear that the first investment alternative is the winner. But when looking at the consumptions, the decision goes in the direction of the second alternative:

Utilities consumption	**Investment 1**	**Investment 2**
Gas	↓ 22,29%	↓ 31.56%
Electricity	↓ 65,86%	↓ 71.69%
Water	↓ 8,23%	↓ 4.80%
Total	**↓32,13%**	**↓36,02%**

Fig. 6. Estimated utility consumption savings.

Although, the advantages of investing in a BMS do not refer only to the energy and cost savings. Due to the modern technology, there are also benefits such as:

- The result of the digitalization:
  - Monitoring of the utility consumptions and possibility to adapt the equipment for a more efficient use;
  - Managing the alerts for emergency cases;
  - Monitoring and controlling all equipment;
  - Overview of whole activity of the building;
- The reduction of CO_2 emissions;
- The increased comfort and satisfaction for the building's occupants and therefore increased productivity;

The final decision of the facility manager regarding the best alternative for investing in a BMS that fits the need of the office building depends first of all of the openness of the company to the new digitalized world, but most of the company's investment strategy.

5. Conclusions

In a technologized era, there is a need for a shift from the traditional work to a digitalized process-based management, with data-driven decisions that can improve a company's performance.

Modernization through digitization and restructuring of economic activity has a beneficial effect on economic efficiency, both through the efforts made to promote the modernization pathways and the economic effects of this action. From the point of view of the economic effects, this type of activity has several advantages, but the most important one is considered to be the influence it exerts on the qualitative sides that it determines.

Studies show that investments in equipment and technology integrated into facility management activities can lead to cost efficiencies of up to 30% within a company, as facility management is the second largest cost center in an organization. Early identification of the need for investment, optimization and efficiency is vital for a good adaptation to new reality, innovation and progress. The economic efficiency of investments is a fundamental issue in facility management and a project will be effective if the calculated efficiency indicators meet the general requirements of the organization.

From a technological point of view, the investment of a company in a BMS is beneficial both to the building owners (equipment control and monitoring, reduced risks, flexibility, energy efficiency and increased operating savings, high revenue from perceived rents) and building's occupants (control, productivity, comfort, financial savings and maintenance time).

Started from all aspects listed in this paper, the facility management sector is, in this case, the key to the evolution and success of a company, because based on a digitalized support, the facility manager with its team can ensure that facilities are functioning properly, can improve their efficiency by having a complex overview of their status and can anticipate and prevent actions with negative impact on the buildings, their occupants and on the company as a whole. It can align the facilities to the strategy of the company by controlling the value and efficiency of investments and long-term costs.

References

[1] *Checkit,* "The 4 benefits of digitizing facilities management", 2016, https://www.checkit.net/the-4-benefits-of-digitising-facilities-management/.

[2] *G.C. Kane, D. Palmer, A.N. Phillips, D. Kiron, Buckley,* "Aligning the Organization for Its Digital Future," in **MIT Sloan Management Review**, Summer 2016, Deloitte University Press, in http://img04.en25.com/Web/JLLAmericas/%7B8d3fceb1-b108-4863-b7da-b37569c201dd%7D_reinventing-facilities-management-for-the-dgital-world.pdf.

[3] *JLL*, "Reinventing facilities management for the digital world", White Paper, 2016, http://img04.en25.com/Web/JLLAmericas/%7B8d3fceb1-b108-4863-b7da-b37569c201dd%7D_reinventing-facilities-management-for-the-dgital-world.pdf.

[4] *JLL*, "Reinventing facilities management for the digital world", White Paper, 2016, http://img04.en25.com/Web/JLLAmericas/%7B8d3fceb1-b108-4863-b7da-b37569c201dd%7D_reinventing-facilities-management-for-the-dgital-world.pdf.

[5] *C. Talon*, "Building The Future Through Digitalization", 2016, https://www.forbes.com/sites/navigant/2016/05/04/building-digitization/#7bd4e0993ce6.

[6] *Checkit*, "The 4 benefits of digitizing facilities management", 2016, https://www.checkit.net/the-4-benefits-of-digitising-facilities-management/.

[7] Honeywell, "An Overview to BMS", http://www.controlead.com/media/downloads/BMSOverview.pdf.

[8] *C. Talon*, "Building The Future Through Digitalization", 2016, https://www.forbes.com/sites/navigant/2016/05/04/building-digitization/#7bd4e0993ce6.

[9] *Baunetzwissen Sicherheitstechnik*, "Betriebsdatenerfassung BDE", http://www.baunetzwissen.de/standardartikel/Sicherheitstechnik_Betriebsdatenerfassung-BDE_165046.html.

[10] BTG Romania, http://btgromania.ro/.