THE IMPORTANCE OF FACILITY MANAGEMENT IN THE LIFE CYCLE COSTING CALCULATION

Ana MUNTEANU[1]
Gabriela MEHEDINTU[2]

Abstract: *During the last decades, the technological development, including the production of materials, buildings and services, brought about good changes in our life style, and, unfortunately, not so good changes in the environment. That is why, people started to be more aware of the impact of a product/ building/service life cycle on the environment and on the living beings. This paper looks at what facility management and life cycle are, at the phases of the life cycle costing according to facility management, life cycle costs of buildings, the impact of facility management on the life cycle costing calculation of buildings, and, last but not least, we will give an example of a life cycle calculation for two alternative investments in two-floor buildings to underline the necessity of knowing LCC while making an investment decision.*
Keywords: environmental management, facility management, life cycle, life cycle cost
JEL Classification: M19, Q56, R20, Y80

1. *Introduction*

During the last decades, people have been more and more aware of the impact brought about by the technological development, including the production of materials and services, on the environment and on all living beings. That is why, all companies, in fact, all business entities that offer material goods and services started to pay special attention to the way they

[1] *Spiru Haret* University, Faculty of Legal, Economic and Administrative Sciences Brasov, Romania, e-mail: anamunteanu.engleza@gmail.com.
[2] PhD Candidate in Construction Management at the Technical University of Civil Engineering Bucharest, Romania, e-mail:gabrielamehedintu@yahoo.de.

manufacture their products and offer their services. More than that, they started to be aware of their means of exploitation and / or use, decommissioning and recovery and / or recycling. This implied the thorough analysis of the life cycle, i.e. each stage of the product's manufacture, exploitation, decommissioning, recovery / recycling. This also implied facility management, due to its main aim: coordinating a business entity's assets and services which is best done by improving the entity's sustainability by implementing a life cycle analysis for the facilities.

For the above reasons, we will further look at what facility management and life cycle (costing) are, at the phases of the life cycle costing according to facility management, life cycle costs of buildings, the importance of facility management in life cycle costing calculation, and, last but not least, we will give an example of a life cycle cost calculation for two alternative investments in two-floor buildings to show the necessity of knowing LCC while making an investment decision.

2. Facility management and the life cycle

According to the European Committee for Standardization (2006), facility management (FM for short) is defined as the 'integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities'. Within an organization, through the coordination of its assets and services, technical and economic knowledge, using managerial skills and adapting continuously the organizational environment, the facility management functions as an integrated process. Hence, it influences positively the organization's ability to act proactively, to optimise the capacity and the runtimes of the assets, to provide added value to them and to the buildings. It should be well known that facility management improves the processes within an organization by reducing long-term operating and management costs and flexing the fixed costs. In short, good facility management helps develop the entire business.

User satisfaction and well-being in buildings are getting more and more important in facility management. They are supported by customized design of real estate and the optimisation of the life cycle, as can be seen in the German Facility Management Association (GEFMA for short) Directive 100-1.

According to the ISO 14040:2002, the term ‘life cycle’ is defined as the ‘consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal’.

When referring to a construction project, given its peculiarities, the whole history of the life cycle should be considered, from the moment of conception to the moment the building is demolished or the moment the destination of the building is changed. Figure no. 1 shows the extended life cycle of a building project.

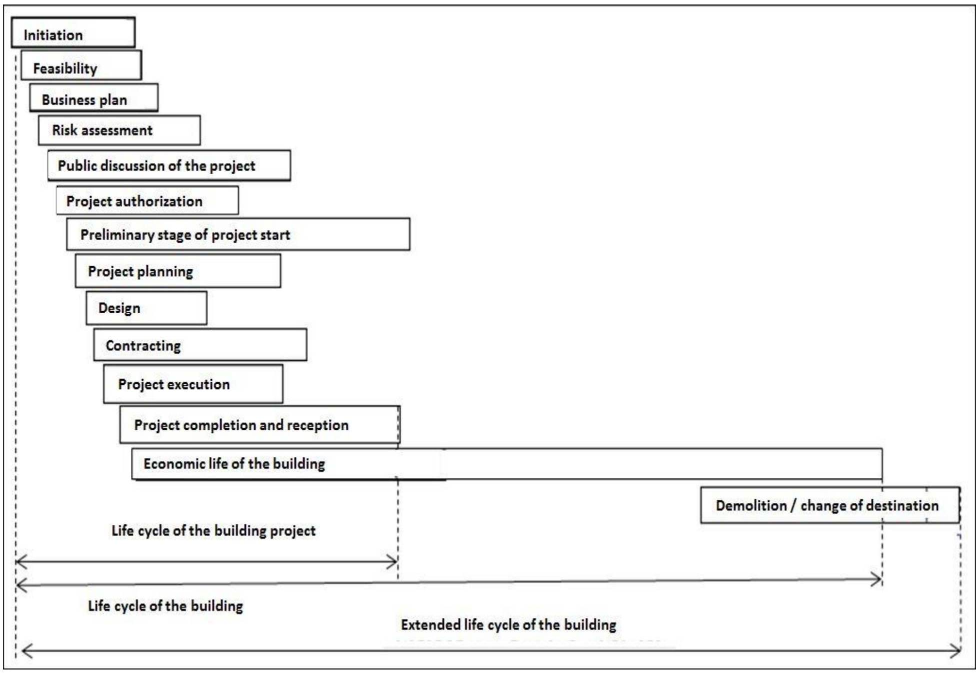

Figure no. 1. Extended life cycle of a building project

Source: Own representation based on Antohie, 2011.

According to facility management, Heller forth (2001) divides the phases of the lifecycle into six steps: identifying the needs, designing the planning and the approvals, production, commissioning, the use, recovery. All these steps highlight the activities of the construction operator: for example, identifying the needs is just one aspect of the initiation. Commissioning is for facility management, together with relocation management, an activity full of responsibility, but in terms of the building, it is only a transitional phase.

Very similar to the above classification is the one given by the GEFMA Directive 100-1: 2004: initiation, planning/design, construction, commissioning, purchase, operation and use, refurbishment / reuse – renovation / modernization, vacancy, recovery. The name 'recovery' given to the last phase also implies a new recovery of the construction elements (in environmental terms), as well as the sale of the land.

The advantage of the graphical representation given by GEFMA, as you can see in Figure no. 2, is the concentric semi-circular arches that highlight the options at the end of each phase. For example, one of the following steps can be taken after the construction: commercialisation, acquisition or non-occupation.

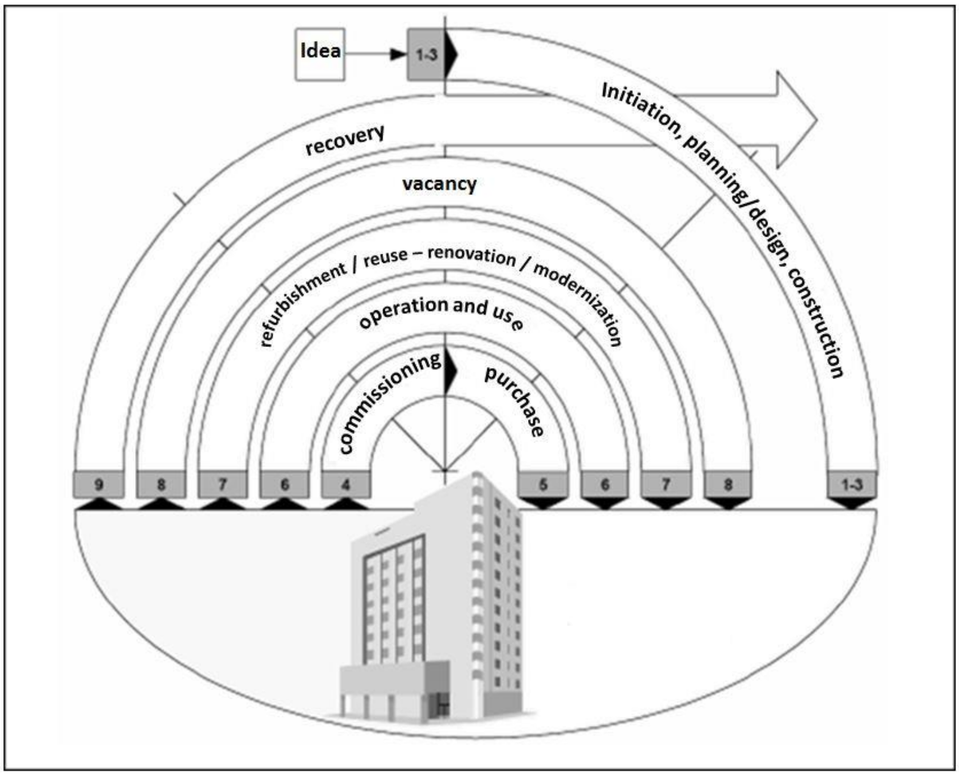

Figure no. 2. Phases of lifecycle

Source: GEFMA Directive 100-1: 2004.

3. *Life cycling costing (LCC for short)*

The concept of LCC comes from the US and was introduced in 1960 by the Logistic Management Institute. It comes from the military field and the calculation methods have been developed and have become widespread by the Ministry of Defence of the USA. In the 1970s the concept was used in the public construction sector.

ISO 15686-5: 2008 defines LCC as 'a valuable technique that is used for predicting and assessing the cost performance of constructed assets'. This ISO also specifies that LCC is 'one form of analysis for determining whether a project meets the client's performance requirements'.

At the national levels, the following standards are:

- ASTM E 917-02: 2002: *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems* (USA),
- NS 3454: 2000: *Life cycle costs for building and civil engineering work* - *Principles and classification* (Norway),
- AS/NZS 4536: 1999: *Life cycle costing* - *An application guide* (Australia/New Zeeland), this being developed without reference to the real estate field.

These three standards are at the basis of ISO 15686, but none highlights concrete methods of calculation.

In Germany there are no regulations for the calculation of the LCC of public constructions. They apply *The principles of efficiency and saving* from the Budgetary Principle Law (HgrG) of Article 7 of the Regulation Budget of the Federation (Bundeshaushaltsordnung).

According to GEFMA, in terms of facility management, LCC is defined as 'costs that arise during the life cycle, regardless of the time of their formation'. This tool was developed primarily to assist managers in making decisions based on achieving a systematic assessment of life cycle costs of the assets, with the aim of developing long-term prospects. Managers should make decisions regarding the acquisition and continuous use of various assets, including equipment and storage facilities. The initial capital costs are usually clearly defined and often key factors, influencing the choice of assets. This is however only part of the life cycle costs of an asset. The identification and documentation of all costs incurred throughout the span life of an asset is the life cycle cost.

For a building, the estimation and the control of the cost of a work are essential. A construction project can proceed only if the costs are estimated and the execution budgets are initiated. During the execution it is essential that all the expenditure on labour, materials, machinery and equipment, etc., be calculated and compared with the initial budgets so that they do not exceed the established limit.

Knowing the life cycle cost is also important to achieve high monetary values from the buildings and constructed assets acquired and used. The ultimate goal of knowing the lifelong building costs is to lower these costs.

At the analysis of the cost throughout the life cycle, it appears that, by the stage of commissioning the building, the initial costs start from a maximum, reaching to up to 10-15% of the costs (see the blue line in Figure 3). Then, starting with the stage called 'use', up to the 'recovery' phase, these costs remain almost constant under an average of 10%, with a downward trend. In these periods fluctuations in costs may occur periodically due to the maintenance, renovations, minor refurbishing activities, all related to facility management, which have no impact on the operating costs. Still it is good to take all of them into account, starting with the construction design phase.

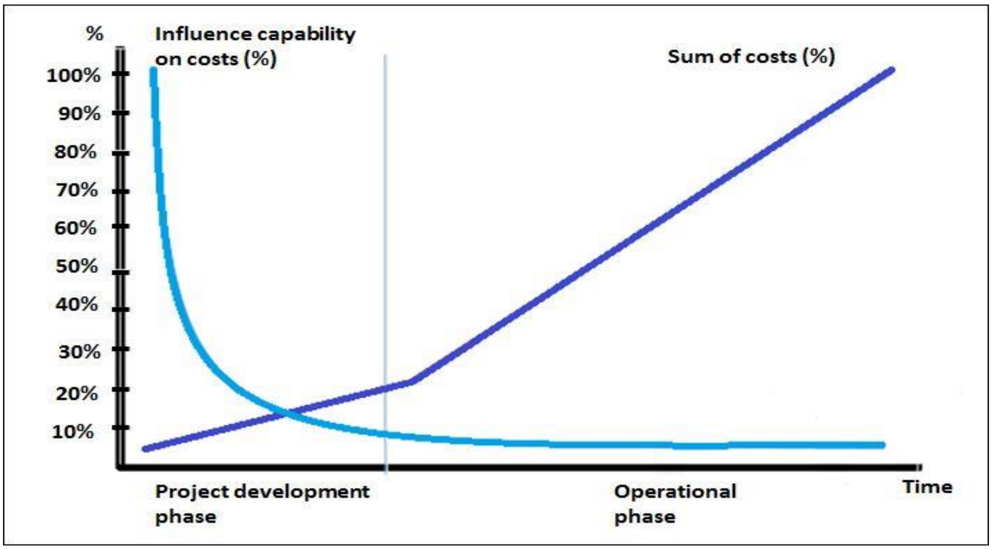

Figure no. 3. Life cycle cost analysis of buildings

Source: ROFMA, 2012.

When talking about the cumulative cost of the life cycle, it is noted that although the initial unit costs, the design and execution costs represent a maximum of the investment, they actually do not exceed 15-20% of the total of the LCC as it is shown in ISO 15686-5: 2008. Thus, it is worth noting that in general during the lifetime of a building, the operation and maintenance costs will far exceed the initial construction costs, going up to 80-85% of the total costs as shown in Figure no. 4.

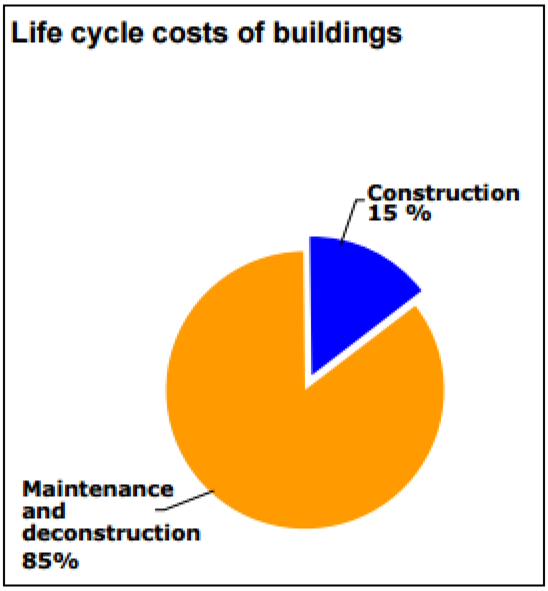

Figure no. 4. Life cycle costs of buildings

Source: ISO 15686-5: 2008.

4. The importance of facility management in the life cycling costing

It is important to know the costs of facility management in all the phases of the life cycle of a building since it leads to relevant managerial decisions of investment and well-founded by estimating the complete costs, leading to a better building design (taking into account all the aspects connected with the life span of the building). Relevant to the importance of knowing the costs of FM are also arguments such as: building conservation by keeping it in good running conditions, so avoiding early deterioration; maintenance costs are kept at a constant and low level, avoiding major investments in the rehabilitation of the building, which involve activities that can damage / disturb the operational activities; ensuring the safety of each operation; maintenance of goods. In other words, we are talking about maintaining the building's value.

The implementation of the consideration of life cycle costs helps improve the sustainability of the investing organization by reducing long-term costs (saving) and the long-term prospects of investment decisions.

To develop a sustainable and investment efficient building, it is important that the issues related to FM be involved in all the phases of the building life cycle, because it affects its total cost.

5. Measures of economic evaluation – Calculating the life cycle cost

In the economic evaluation, one option of calculation is the analysis of the life cycle that can be used for the investment alternatives that generate different costs during the life cycle of a building. These buildings are updated at some point, and the option considered the most economical is the one generating the lowest updated cost.

This tool is the best suited to make a fair comparison between the projects with high initial costs and future operating costs and low recovery and the alternatives with a reduced initial cost, requiring higher future costs. In this regard, it is highlighted the need to know all the elements that form the structure of the total life cycle cost.

Most specialists, for example the authors from INCERC (2010), S. Lambrache among them, consider that the most important benefit of an analysis of the life cycle cost arises when it is performed before the start of the actual execution. This is because during the design period the specifications may be changed without generating additional high costs. When the construction was already made or when changes occur during the execution period, the impact on costs is much greater. Therefore, it is very important that the original structure of the life cycle cost include all the cost categories with a major impact on the total life cycle cost.

Studying *Literature review of life cycle costing (LCC) and life cycle assessment (LCA)* we agree with the following facts: project costs that occur at different points in the life of a building cannot be compared or summed directly due to the varying time value of money. They should be discounted back to their present value through the appropriate equations. Firstly, costs must be converted into their time-equivalent value at the base date before being combined to compute the LCC of a project phase or of a whole project. This time-equivalent value is referred to as the Present Value (PV) of the costs. The discount rate is the interest rate used to convert (or 'discount') future expenditures to their present value at the base date, taking into account the investor's time value of money. The discount rate selected for LCC analysis should make an investor indifferent to a future cash amount and its present value.

According to the report TG4 (2003), LCC in construction is calculated as a present value of the accumulated annual future costs (C) over a period of analysis time (t), at an agreed discount rate (d), dependant on prevailing interest and inflation rates.

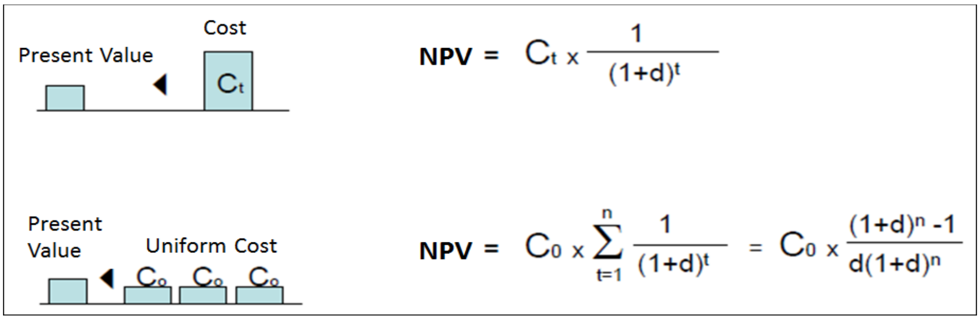

Figure no. 5. Net Present Value calculation

Source: Alfen, H. W., Kiesewetter, F., 2009.

As Davis Langdon Management Consulting (2006) say, in LCC analysis, all relevant present and future costs (less any positive cash flows) associated with an energy system are summed in present or annual value during a given study period (e.g., the life of the system). These costs include, but are not limited to, energy, acquisition, installation, operations and maintenance, repair, replacement, inflation, and discount rate for the life of the investment (opportunity cost of money invested). Mathematically, we can express the above ideas like this:

$$LCC = I + Repl - S + O + MM\&R$$

where:

I = initial cost (investment cost);
Repl= Replacement costs;
S = Residual value (the resale value at the end of study period);
O = Operating cost (energy, water);

MM&R = management, maintenance and repair costs = facility management costs.

The NPV method is advantageous because it takes into account the time value of money, aspect forgotten by other methods. However, NPV is only an estimation, sensitive to changes in estimates of cash flows, value recovery and cost of capital, which above all, does not take into account the size of the project.

In order to show that it is important to known the facility management costs in the LCC from the beginning of the investment, we will give an example of LCC calculation for two alternative investments in two-floor buildings.

General parameters:
Discount rate: 3%
Energy costs: 0.09 €/kWh
Economic Life: 20 years
Period of analysis time = 20 years (n)
Base date = 2016

Table no. 1. General parameters for both alternatives

Parameters	Alternative A (€)	Alternative B (€)
Initial investment	105,000	115,000
Replacement at the end of year 12	11,000	11,500
Residual value after 20 years	4,000	4,200
Energy cost (p.a.)	22,500 (250,000 kWh x 0.09 €/kWh)	14,625(250.000 kWh x 0.09 €/kWh)
Management, maintenance and repair costs (p.a.)	8,000	9,000

Table no. 2. Alternative A

Cost elements	Cost at base date	Year occurrence	Discount rate	NPV
Initial investment (I)	105,000	2016	Already present value	105,000
Replacement costs (Repl)	11,000	2028 (2016+12)	0.701 (1)	(11,000 x 0.701) 7,711
Residual value (S)	-4,000	2036(2016+20)	0.554 (2)	-2,216
Energy cost (O)	22,500	annual	14.877 (3)	334,733
MM&R	8,000	annual	14.877 (3)	119,016
LCC				**568,676**

The discount rate for the replacement costs:

$$\frac{1}{(1+d)^t} = \frac{1}{(1+0{,}03)^{12}} = 0.701 \quad (1)$$

The discount rate for the residual value:

$$\frac{1}{(1+d)^t} = \frac{1}{(1+0{,}03)^{20}} = 0.554 \quad (2)$$

The discount rate for the energy costs and management, maintenance and repair costs, in fact, the facility management costs:

$$\frac{(1+d)^n-1}{d(1+d)^t} = \frac{(1+0{,}03)^{20}-1}{0{,}03(1+0{,}03)^{20}} = 14.877 \quad (3)$$

Table no. 3. Alternative B

Cost elements	Cost at base date	Year occurrence	Discount rate	NPV
Initial investment (I)	115,000	2016	Already present value	115,00
Replacement costs (Repl)	11,500	2028 (2016+12)	0.701 (1)	8,062
Residual value (S)	-4,200	2036 (2016+20)	0.554 (2)	-2,327
Energy cost (O)	14,625	annual	14.877 (3)	217,576
MM&R	9,000	annual	14.877 (3)	133,893
LCC				**476,858**

If the two alternative LCC values are compared, it is found that alternative B is more effective:

LCC of alternative B < LCC of alternative A

476,858 € < 568,676 €

We can notice that in project A the energy costs are higher than in project B (a very important thing when compared with the initial investment) and the costs that include FM (i.e. MM & R in the formula) are slightly larger in project B, but overall project B is more profitable.

In conclusion, the major difference between the two alternatives is given by the energy costs, an important reason which supports the necessity of knowing the facility management costs in the LCC while making an investment decision.

6. Conclusions

Both the LCC and the facility management costs are important to know in all the phases of the life cycle of a building since this knowledge leads to relevant managerial decisions related to the investment.

The LLC structure is represented by two categories of costs: initial and subsequent. The initial costs are those related to the design and execution; the others consider the use and the recovery period. It is desirable that they should be estimated during the phase of analysis of the alternatives for design and execution, the accuracy of their estimation depending on the accuracy of anticipation for the period of operation. Therefore, in determining the LCC is important to consider all the operating costs including those related to FM, fact which attaches great importance to FM in all the phases of the life cycle of a building. Thus the costs of maintenance, repairing and rehabilitation and the energy consumption costs are decisive.

References:

1. Alfen, H. W., Kiesewetter, F., (2009). *Lifecycle Kosten und Facility Management*, Summer School 2009 Bauhaus-Universität Weimar at http://web.uni-weimar.de/cms/fileadmin/bauing/files/professuren/baubet/Publikationen/Alumni/Alumni2009_Lifecycle_FacManagement.pdf
2. Antohie, E., (2011). *Ingineria costurilor* (*Engineering Costs*), Iaşi: Editura Societatii Academice 'Matei-Teiu Botez'.
3. ASTM E 917-02 (2002). *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*, USA.
4. AS/NZS 4536 (1990).*Life cycle costing - An application guide*, Australia/New Zeeland.
5. *BHO (Bundeshaushaltsordnung) § 7: Wirtschaftlichkeit und Sparsamkeit, Kosten- und Leistungsrechnung*, published 22.12.1997.

6. Davis Langdon Management Consulting (2006), *Literature review of life cycle costing (LCC) and life cycle assessment (LCA)*. Draft Literature Review for LCC Methodology Project.
7. European Committee for Standardization (2006).EN 15221-1: 2006. *European Standard* FM_ISO_TC_267_SC_N_5.pdf
8. German Facility Management Association (GEFMA) Directive 100-1: 2004.
9. Hellerforth, M. (2001). *Facility Management - Immobilien optimal verwalten*. Freiburg i. Breisgau.
10. HGrG (1969), *Haushalts Grundsätze Gesetz*.
11. Institutul National de Cercetare-Dezvoltare in Constructii si Economia Constructiilor-INCERC, (2010). *Analiza costurilor pe ciclul de viață al construcțiilor, în contextul dezvoltării durabile – COSTCONS* (monografie) (The analysis of the life cycle costs of the buildings, in the context of sustainable development – monographic study), Bucureşti: ASE.
12. ISO 14040:2006(en).*Environmental management – Life cycle assessment – Principles and framework* at https://www.iso.org/obp/ui/# iso:std: iso:14040:ed-2:v1:en (accessed in December 2015)
13. ISO 15686-5: 2008. Buildings and constructed assets – Service life planning – Part 5: Life-cycle costing at https://www.iso.org/obp/ui/#iso: std:iso: 15686:-5:ed-1:v1:en (accessed in December 2015)
14. NS 3454 (2000).*Life cycle costs for building and civil engineering work - Principles and classification*, (Unauthorized translation made by the Norwegian Council for Building Standardization).
15. Task Group 4 (TG4).The European Commission, (2003).*Report of Task Group 4: Life Cycle Costs in Construction.*
16. http://www.rofma.ro (accessed in December 2015).