Building Information Electronic Modelling (BIM) Process as an Instrumental Tool for Real Estate Integrated Economic Evaluations

Mohsen Shojaee Far
Centre of Land Policy and Valuations (CPSV), Polytechnic University of Catalonia, Barcelona, Spain

Ioanna Alsasua Pastrana
Architect and BIM Expert at SIMBIM™ Solutions (GRAPHISOFT ArchiCenter), Barcelona, Spain

Carlos Marmolejo Duarte
Centre of Land Policy and Valuations (CPSV), Polytechnic University of Catalonia, Barcelona, Spain

Abstract

The initial costs of a building are quite small in comparison to the life-cycle costs, as it is estimated that they represent less than 30% of the total life-cycle cost of a building. Accordingly if we consider integration of the life-cycle cost of a building into the estimation of investment values, then we would have a better and clearer idea of how much our total operation costs is during and after construction process. This integration possibility would positively affect the decisions of private investors about their investment and also assist the public sector to decide on better proposals for civic buildings, where integration of running cost into total investment may provide more efficient decisions. However, traditional forecasting methods are not accurate, and it may not demonstrate the reality. Therefore the main focus of this study is an investigation on a practical and instrumental methodology based on technological possibilities in the AEC industry, where integration of building information electronic modelling (BIM) processes into real estate economic evaluations suggested. Findings of this study demonstrate the opportunities to manage and estimate a reliable and accurate information on a building’s life cycle in real time by considering each element and its components into the calculation, which may change the metrics for a real estate economic evaluation in order to achieve sustainable and efficient property investment towards smart city agendas.

Keywords Life Cycle Cost Analysis (LCCA), Building Information Modelling (BIM), Real Estate, Integrated Economic Evaluation, ArchiCAD, CYPE, Smart City

1. Introduction

The initial costs of a building are quite small compared to the life-cycle costs, as it is estimated that they represent less than 30% of the total life-cycle cost of a building
Asset, Property & Facility

This is significantly important from the perspective of an investor in terms of the total cost and value of an investment.

While traditional economic valuations for real estate focus on the market value of the asset, investors generally evaluate an investment’s opportunity by understanding the relationship between the investment cost and value. This issue can impact other values, such as physical, social, environmental and economic factors that might act as elements of the decision-making process for an investor (RICS, 2014). However, it is quite difficult to collect and take the appropriate data into account.

This study focuses on the integration of the life-cycle cost of a building into the estimation of traditional investment values to be able to have a better and clearer idea of the total operation cost during and after construction. This integration possibility may positively affect the decisions of private investors about their investment, however the greater impact will be on public sector investments, where it assists the public sector to decide on better proposals for civic buildings. Correspondingly, the integration approach of running cost into total investment may provide more efficient decisions. Additionally, the life-cycle cost analysis is not limited to just new construction, it also includes the renovation and maintenance of existing facilities.

However, even if traditional life-cycle cost analysis methods were developed over the last 30 years to enable us to compare cost assessments over a specific period of time, there is still a debate on the parameters that should be considered in life-cycle cost and also on which is the best methodology to calculate them. Accordingly, life-cycle techniques have been criticized for being based on forecasts of future events, and involvement of many variable factors caused the chance of inaccuracy in forecasting (Flanagan, Jewell, & Norman, 2005). Unfortunately, the cost of investigation and analysis of elements breakdown to develop an accurate forecast is not feasible in our current systems, where the measurement of the accurate life-cycle cost of a design is almost unreachable in traditional systems.

There are various methods of real estate valuation and the common objective within all of them is to determine a value based on the evidence that is usually obtained through a comparative analysis of similar conditions. However running cost is more important in investment value than in market value (TEGOVA, 2012). This type of assessment gives opportunities to indicate the price that can be most likely achieved in a hypothetical exchange in a free market (IVSC, 2011). Also, there are several definitions to determine investment value, where generally it is highlighted as a subjective process of the value estimation of an asset according to the perspective of the investor or operational objectives (REP, n.a.; IVSC, 2011; PRE, 2014). Therefore, the investment value is a subjective factor in addition to the market value, which may act as the key factor in an investor’s decision-making process. There is a wide range of physical, social, environmental and economic factors that can impact value. However, it is not always possible to collect and consider the appropriate and sufficient data.

The possibilities that are offered by Information technology associated with the development of cutting-edge solutions, such as building information modelling (BIM), building energy modelling (BEM), MEP modelling (mechanical, electrical, and plumbing), and many other parameterizing modelling techniques have opened the opportunity to manage and estimate reliable, accurate information on a building’s life.
cycle in real time by considering each element and its components into calculation, which may change the metrics for a real estate economic evaluation. In order to control and evaluate the real total cost of a property, in both new construction and renovation/maintenance projects, life-cycle cost analysis (LCCA) must be integrated into existing tools that are traditionally used in the construction process (BIM, BEM, MEP, BIM-FM, etc.) suggested by this study as a key decision-making tool for the public and private sectors.

The methodology of this study is based on documentary investigation and empirical analysis throughout technological tools. While documentary investigation allows the study to determine the parameters and methodology of life cycle cost analysis, an empirical study and analysis developed by Building Information Electronic Modelling tools. The empirical stage of this study demonstrates an instrumental methodology to integrating life cycle cost analysis into real estate economic evaluations. This empirical investigation is based on the combination of BIM for building elements cost calculation and BEM for energy evaluation and consumption calculation. For the purposes of this study, an imaginary public building that functions as a small exhibition centre has been taken into account, where Graphisoft ArchiCAD has been used as the BIM authoring application to generate the model and run relative cost and energy evaluations.

2. A brief overview on Life-Cycle Cost (LCC)

The European approach of Life-Cycle Cost (LCC) is considered by the EU commission as total cost of ownership, or in other words, the cost of a good or service over its entire life cycle (EC-Environment, 2015). In this definition, LCC is categorized into four cost elements of investment, operation, maintenance, and disposal costs, which are determination cost factors in most assessment methods. The general European approach to such assessments is comparative cost assessments over a specific period of time, considering all LCC indicators, which are initial, operational, and replacement costs. This type of assessment is internationally known as Life-Cycle Cost Analysis (LCCA). Although consideration of LCC is not enforced in any specific European legislation, Economically Most Advantageous Tender (EMAT) was introduced as an option in EU directives related to public procurement directives (European Commission, 2007). Yet just a few investors, according to a EU commission report, have taken LCC into consideration for their construction work and estimation. The brief review on definitions and elements of LCC clearly shows that Construction Cost (CC) is part of LCC as the initial cost of investment.

Also, similar to the EU commission, ISO standard (15686-5) introduced the LCCA of a building and construction asset and considered the subjective investment value integrated into LCCA as a comparative analysis between different alternatives to determine the best value per cost (Mearig, Coffee, & Morgan, 1999; Stanford University, 2005; Bakis, Kagiougloou, Aouad, Amarutunga, Kishk, & Al-Hajj, 2003):

“A technique which enables comparative cost assessments to be made over a specified period of time: taking into account all relevant economic factors both in terms of initial costs and future operational costs.” (ISO, 2014)
However, the application of LCCA techniques has been strongly criticized by the Royal Institution of Chartered Surveyors (RICS), where there is still no standard method of measurement of LCC (Kelly & Hunter, 2009). Then, even if LCCs have a big economic impact, the lack of this standardization prevents its incorporation into estate valuation and limits the metrics to accurately analyse the initial costs (construction and land). It is important to consider that LCCA is based on forecasts of future events, which can be inaccurate and involve too many variables, and in consequence, no standardized and practical workflow of LCCA in building design techniques prevent effective use of LCCA in the decision-making process (Lai, Halvitigala, Boon, & Birchmore, 2010).

3. BIM Integrated LCC Evaluations

The estimation of LCC in the first stages of design is based on the comparison with the cost of similar buildings in the past, but as the design evolves in more detail, the life-cycle cost can also be estimated more accurately (Bakis et al., 2003). However, if the individual building components are identified, then the LCC of each of them can be estimated by assigning a certain price, life expectancy, and the frequency of maintenance and operating activities. Therefore, data aggregation by means of integrating all building components costs into the model database to estimate the efficiency and performance of the building can enable the investor to know the running cost of a design proposal. In this sense, the owner has the possibility to know how much the construction process, environmental performance, and future maintenance of a building would cost.

To achieve an integrated evaluation, using parameterised modelling tools that associate geometric models of a building into databases, can be considered as a practical solution. These kinds of applications usually refer to Building Information Modelling (BIM) authoring applications, and the product is a BIM model, which is a reliable basis for decisions during the building life cycle. In a simplified explanation, the BIM technology enables the possibilities to aggregate data from all sources into the model and simulate the building data for many different uses from the earliest conception to the demolition stage, in addition to simulations related to existing buildings. Based on the Computer Integrated Construction research program at the University of Pennsylvania (2011), which identified 25 BIM uses during the life cycle of a facility, this paper considers 3 of them to integrate into economic evaluation of LCC (Table 1). The 3 selected uses are (1) cost estimation with quantity take-off methods, (2) energy consumption analysis, and (3) building (preventative) maintenance scheduling, where the integration and combination of these tools provide an instrumental integrated approach to run more accurate LCCA.
Correspondingly, BIM technology enables us to model and simulate the real construction process and its cost in a virtual environment. This process includes the information and performance of each building element, which provide an estimation possibility of accurate initial cost of a building, as well as the renovation cost. Building energy modelling (BEM) can be performed either in external applications or directly inside a BIM authoring program (i.e. the Eco-Designer engine within Graphisoft ArchiCAD), in which it analyses the parametric model in terms of environmental behaviour and energy consumption. Accordingly, estimations of total cost per year based on systems and sources used in the building could be demonstrated. This would provide the total utility cost needed for the LCCA.

BIM integrated facility management tools (BIM-FM) extract data directly from a BIM model, in which it provides a wide range of functions to support the full maintenance process. The FM-BIM would demonstrate an accurate planning system connected with time and cost and with scheduling and tracking of service and maintenance activities.

### Table 1 – 3 BIM uses to integrate into economic evaluation of LCC (Reference: PSU, 2011, Summerized by Author)

<table>
<thead>
<tr>
<th>Description</th>
<th>Potential Value</th>
</tr>
</thead>
</table>
| Cost Estimation (Quantity Take-offs) | A process in which BIM can be used to assist in the generation of accurate quantity take-offs and cost estimates throughout the life cycle of a project. | • Precisely quantify modelled materials  
• Generate more cost estimates at a faster rate  
• Better visual representation of project and construction elements that must be estimated  
• Provide cost information to the owner during the early decision making phase of design and throughout the life cycle, including changes during construction  
• Easier exploration of different design options and concepts within the owner’s budget |
| Facility Energy Analysis | The BIM Use of Facility Energy Analysis is a process in the facility design phase in which one or more building energy simulation programs use a properly adjusted BIM model to conduct energy assessments for the current building design. | • Save time and costs by obtaining building and system information automatically from the BIM model instead of inputting data manually  
• Improve building energy prediction accuracy by auto-determining building information, such as geometries and volumes precisely from the BIM model  
• Optimize building design for better building performance efficiency and reduce building life-cycle cost |
| Building (Preventative) Maintenance Scheduling | A process in which the functionality of the building structure (walls, floors, roof, etc.) and equipment serving the building (mechanical, electrical, plumbing, etc.) are maintained over the operational life of a facility. | • Plan maintenance activities proactively and appropriately allocate maintenance staff  
• Track maintenance history  
• Reduce corrective maintenance and emergency maintenance repairs  
• Evaluate different maintenance approaches based on cost |
Building Information Electronic Modelling (BIM) Process as an Instrumental Tool for Real Estate Integrated Economic Evaluations

Asset, Property & Facility

maintenance events associated with their cost. This method provides an integrated approach to estimate the whole cost of maintenance and service (Figure 1).

Figure 1 - figure showing data extraction and simulation from an integrated database to generate LCC Database

4. Case Study

The core value of BIM is the information attached to the model. This technology enables the modeller to collect and aggregate data from different sources and run a different series of simulations on them. This way it is possible to produce an automatic and systematic report on final outcomes. This case study explores the use of Graphisoft ArchiCAD, a 30-year-old BIM authoring application, for life cycle-cost analysis for an imaginary exhibition centre project (Figure 2).

Figure 2 - image of the case study project obtained from the virtual model in ArchiCAD

The case study project is an exhibition centre of overall 100m² with a porch of 30m². The building is divided into two stories and is located on a hypothetical plot of vacant land near Barcelona without any nearby structure. To simplify the process and
keep the focus of the study on workflow of the case study, this paper limits itself to this small building with simple functionality. The building has been virtually built in ArchiCAD through a collection of intelligent building elements, which constitute an important database. Throughout this case study a simulation has been run to determine the building performance. The basic specifications of the construction elements are defined in Table 2.

Table 2 – This table extracted from the virtual building (case study) throughout the schedules of ArchiCAD and reflects the information of the main building elements and its composition

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roof</strong></td>
<td>Frame</td>
<td>0.03</td>
<td>3.97</td>
<td>1008.00</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Insulation - Plastic Soft</td>
<td>0.04</td>
<td>5.3</td>
<td>1400.00</td>
<td>0.04</td>
<td>467.67</td>
<td>11751.35</td>
</tr>
<tr>
<td></td>
<td>Membrane - Vapor Barrier</td>
<td>0</td>
<td>0.13</td>
<td>1800.00</td>
<td>0.50</td>
<td>250.58</td>
<td>9958.31</td>
</tr>
<tr>
<td></td>
<td>Timber - Roof</td>
<td>0.02</td>
<td>2.65</td>
<td>2300.00</td>
<td>0.14</td>
<td>476.94</td>
<td>13248.42</td>
</tr>
<tr>
<td></td>
<td>Frame</td>
<td>0.18</td>
<td>23.85</td>
<td>1008.00</td>
<td>0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Flat Roof</strong></td>
<td>Gravel</td>
<td>0.03</td>
<td>0.47</td>
<td>1900.00</td>
<td>1.40</td>
<td>5.22</td>
<td>86.62</td>
</tr>
<tr>
<td></td>
<td>Membrane - Rainproof</td>
<td>0.01</td>
<td>0.08</td>
<td>900.00</td>
<td>0.17</td>
<td>340.66</td>
<td>8483.56</td>
</tr>
<tr>
<td></td>
<td>Insulation - Fiber Hard</td>
<td>0.2</td>
<td>3.39</td>
<td>1510.00</td>
<td>0.08</td>
<td>81.46</td>
<td>7331.74</td>
</tr>
<tr>
<td></td>
<td>Membrane - Vapor Barrier</td>
<td>0.01</td>
<td>0.08</td>
<td>1800.00</td>
<td>0.50</td>
<td>160.5</td>
<td>6378.44</td>
</tr>
<tr>
<td></td>
<td>Reinforced Concrete</td>
<td>0.2</td>
<td>3.99</td>
<td>1000.00</td>
<td>2.50</td>
<td>2317.01</td>
<td>22308.36</td>
</tr>
<tr>
<td></td>
<td>Plaster - Gypsum</td>
<td>0.02</td>
<td>0.27</td>
<td>1000.00</td>
<td>0.57</td>
<td>45.67</td>
<td>632.4</td>
</tr>
<tr>
<td><strong>Ground Floor Slab</strong></td>
<td>Reinforced Concrete</td>
<td>0.2</td>
<td>18.05</td>
<td>1000.00</td>
<td>0.57</td>
<td>10480.59</td>
<td>100908.15</td>
</tr>
<tr>
<td></td>
<td>Insulation - Mineral Hard</td>
<td>0.03</td>
<td>2.45</td>
<td>840.00</td>
<td>0.04</td>
<td>465.22</td>
<td>5977.4</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>0.06</td>
<td>4.89</td>
<td>1000.00</td>
<td>1.15</td>
<td>942.69</td>
<td>6519.55</td>
</tr>
<tr>
<td></td>
<td>Tile - Floor</td>
<td>0.01</td>
<td>0.81</td>
<td>900.00</td>
<td>1.50</td>
<td>781.73</td>
<td>10585.97</td>
</tr>
<tr>
<td><strong>First floor Slab</strong></td>
<td>Plaster - Gypsum</td>
<td>0.01</td>
<td>0.26</td>
<td>1000.00</td>
<td>0.57</td>
<td>43.33</td>
<td>599.89</td>
</tr>
<tr>
<td></td>
<td>Reinforced Concrete</td>
<td>0.2</td>
<td>5.95</td>
<td>1000.00</td>
<td>2.50</td>
<td>3457.08</td>
<td>33285.11</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>0.02</td>
<td>0.52</td>
<td>1000.00</td>
<td>1.15</td>
<td>100.2</td>
<td>692.94</td>
</tr>
<tr>
<td></td>
<td>Timber - Floor</td>
<td>0.02</td>
<td>0.52</td>
<td>2500.00</td>
<td>0.13</td>
<td>83.24</td>
<td>1849.41</td>
</tr>
</tbody>
</table>
### 4.1 Methodology, Results, and Workflow

The methodological approach of this case study is based on the five major categories of purpose and objective of BIM that are defined by Kreider (2010):

1. Gather: collect or organize facility information.
2. Generate: create information databases of a facility.
3. Analyse: examine elements of the facility to gain a better understanding of it.
4. Communicate: present information of a facility in an exchangeable format (i.e. IFC – Industry Foundation Class).
5. Realize: make or control a physical element using facility information.

Not all the BIM uses focus on achieving the five objectives. However, to develop an integrated workflow, this study uses the five objectives as the path to generate a practical solution to integrate BIM into LCCA.

### 4.2 Gather

There are two resources of data to collect and organize information about the facility. The first one refers to the different costs addressed to each building element, and the second one refers to the information needed to simulate the energetic performance of the facility to obtain its utility cost.

#### 4.2.1 Cost elements resource Database:

To be able to gather information for each building element, the cost breakdown structure that is used in this case study is based on their functionality. This way each building element can be connected to an external cost database. This study used BEDEC cost index, developed by the Institute of Construction Technology of Catalonia (ITEC), and it contains information about construction products, such as price,
technical specifications and certifications. The BEDEC is a complex database where different levels of detail can be estimated accordingly, such as material, labour, machinery, and ancillary costs. The database is based on the FIEBDC-3 computer file format (standard exchange format of construction databases), with a direct connection of import and export to Graphisoft ArchiCAD as the BIM authoring application.

4.2.2 Energy resource database:
To be able to run the energy analysis and estimate the utility cost of the project, four necessary sources have been identified:

1. Construction elements of physical properties: They are defined by the characteristics of their own materials, such as thermal conductivity, heat capacity, embodied energy or embodied carbon.
2. Environmental data: Location (latitude and longitude), soil type (thermal conductivity, density and heat capacity), surroundings (whether the building is located in a big city or near water or besides forest), wind protection, shading elements and climate data (air temperature, relative temperature, solar radiation and wind speed). While the first parameters shall be entered manually into the project, ArchiCAD will directly access Strusoft Climate Server, which accurately updates the climate data from around the world, and load the climate data according to the location previously set.
3. Operational Profile: The uses of the facility need to be set. Accordingly, the values of human heat gain, service hot water load and humidity load will be assigned; however, they can also be customized. Schedules of usage shall be set in order to have a more accurate energy analysis in different periods of time.
4. Building systems: This indicates what kind of energy input and output systems are implemented. Sources of energy and cost of the purchased energy are also required.

4.3 Generate
Once the resource databases are identified, it is time of aggregate the different sources of information together through the virtual construction of the facility inside ArchiCAD. Building materials are the base attribute in ArchiCAD to generate the building elements, where building materials are a virtualization of the real materials and not just a graphic representation. In other words, the building materials have associated the physical properties, such as thermal conductivity, heat capacity, and embodied energy or embodied carbon of the same material used in the real construction. The combination of different building materials generates the building elements and composites, such as walls, slabs, roof, etc., in addition to physical properties that are associated to each individual materials (Figure 3).
When the basic building structure is modelled, the rest of the building elements can be introduced into the model, such as doors, windows and skylights. ArchiCAD recognizes those elements as parametric GDL objects (Geometric Description Language) that can be customized according to the necessities of any project. Each opening element item also contains information related to orientation, glazed area and frame perimeter, glazed and opaque area U-value, TST or Total solar transmittance that the percentage of incident solar radiation transmitted by an object includes the direct Solar transmission (DST), in addition the part of the solar absorption reradiated inward and infiltration.

Therefore, as the model has more details, the analysis will be more accurate. Correspondingly, in the element cost breakdown defined for this case study, each building element is linked with the external database of BEDEC. First of all, in an external cost estimation program, in this case CYPE Arquimedes, the same breakdown of elements is set to generate a cost of construction database with the same level of detail of the elements breakdown that has been set in the model. For instance, for an interior wall element in ArchiCAD (1mm Gypsum Plasterboard+ 8mm Air Space+1mm Gypsum Plasterboard), Arquimedes has the same interior wall item, which gathers the information of the cost of its individual elements, including labour, materials, machinery and ancillary costs (Figure 4 and 5).
Figure 4 - screenshot from CYPE Arquímedes which shows the breakdown of cost structure inside the program, each line shows a “building solution” i.e. 1mm Gypsum Plasterboard+ 8mm Air Space+1mm Gypsum Plasterboard interior partition, with its related cost. Each line has a code that will be assigned to the same element in ArchiCAD. For each project we prepare a breakdown cost structure in Arquímedes showing just the elements that are in the project.

Once the specific database for this project is set, each element will have a specific code, which is linked to the building elements in ArchiCAD in order to communicate both applications in a bidirectional way.

Figure 5 - a wall sample, in which we can see the description of the composite of the wall in Arquímedes with the price associated and a certain code. At the right we can see a wall in ArchiCAD with the same composite that is already linked to the database of Arquímedes with the same code.

The next step in this case study is introducing specific data for energy analysis, such as the environmental data, operational profile and building systems, which have been described in the previous section. Graphisoft ArchiCAD has an integrated energy
evaluation tool, which offers an accessible workflow for performing dynamic building energy calculations (Figure 6).

Figure 6: screenshot from ArchiCAD energy evaluation in which we can see the interface to introduce the location and climate data into ArchiCAD. With the climate data, ArchiCAD shows diagrams for air temperature, relative temperature, solar radiation and wind speed yearly, monthly, daily and per hours.

This is not the only way in which we can associate external cost to ArchiCAD building elements. For instance, throughout IFC labels many types of data can be attached to each building element, including construction, maintenance and replacement cost. Also, the costs related to maintenance and replacement have not being associated with the elements, due to the lack of resource database for those parameters as the second limitation to this case study. While in other countries like the United Kingdom we can find the Building Maintenance Pricing Data (RICS 2015), which covers all aspects of maintenance work, such as repairs, refurbishment, and demolition, in Spain the comprehensive database for maintenance are relatively new. However, the workflow demonstrated for the construction cost can be set in the future for the rest of the costs.

4.4 Analyse and Communicate

To be able to simulate the future building performance and obtain the LLC costs, we need to internally analyse the energy efficiency of a facility in addition to communicating the information generated with external applications for more advanced databases or simulations. According to Kreider’s (2013) definition, the communication stage is to present information about a facility in a method that can be shared or exchanged. The established workflow of connection between external cost database with the ArchiCAD model enable this study to extract the information from the authoring application in FIEBDC-3 format and read it in the cost estimation program to generate the final results. Therefore, the final results are based on the combination of the initial cost information of each element and the quantity take-off.
list from the virtual construction made in ArchiCAD. Comparing this method with the traditional workflow, which should quantify the elements in a manual way, the quantity take-off process requires significant effort and time that may be associated with possible errors.

To be able to run energy consumption cost or utility cost simulation, it is necessary to define the thermal blocks of the project, which are each a collection of one or more rooms or spaces in the building that have a similar orientation, operation profile and internal temperature requirements (also called thermostat control requirements). After the thermal blocks are defined (in this case, exhibition area, restroom and entrance) the architectural model (BIM) can be transformed into a Building Energy Model (BEM) by the automatic model geometry and material property analysis functionality of ArchiCAD. The outcome of this simulation (Figure 7 and 8) is a report, which contains information, such as the project’s energy related to structural performance, yearly energy consumption, energy balance, and carbon footprint.

![Energy Performance Evaluation](image)

Figure 7 - the energy evaluation report indicates detailed information through diagrams. When expressing the consumption of energy, it separates the energy used and energy wasted during the using period. It shows the energy consumption by targets or the energy consumption by sources, between other parameters.
Building Information Electronic Modelling (BIM) Process as an Instrumental Tool for Real Estate Integrated Economic Evaluations

Asset, Property & Facility

4.5. Realize

This stage aims to control, partially or completely, an existing facility, proposed design, and investment decision-making process by using generated information. Accordingly, in the case of LCCA, the integrated database built throughout the virtual modelling process (BIM) allows investors to realize, and consequently control the total cost of an investment, including both initial and future running cost. Therefore, based on design decisions, and in order to achieve sustainable and efficient property investment, the BIM model becomes a live database of an existing or future facility. This final stage, where all data has been realized through accurate reports and simulations, demonstrates the possibilities of the different choices that directly impact the total cost and also provides a more accurate vision of the future costs.

5. Conclusion

The findings of this study demonstrate the opportunities to manage and estimate reliable and accurate information on a building’s life cycle in real time by considering each element and its components into the calculation via BIM tools and a series of simulations, which may change the metrics for a real estate economic evaluation in order to achieve sustainable and efficient property investment. Although BIM-FM tools are not simulated throughout the case study, the study shows the possibilities of BIM-FM as an instrumental solution for maintenance and service cost calculations during the life cycle of a building. Correspondingly, this study demonstrates the possible workflow and methodology in relation to the maintenance condition and is aligned with current legislation that is responsive to a level of energy efficiency.

Since the LCCA methods are not just limited to new construction, it will also have a big impact on the renovation and maintenance of existing built environment. Over the last few years, and due to the crisis in AEC industry of Spain, the main attention has changed from new construction to the rehabilitation and renovation of the existing building stock. In 2013, a new law was elaborated (Ley 8/2013, de 26 de junio, de rehabilitación, regeneración y renovación urbanas), in which it requires an evaluation report of the buildings to make sure the building stock meet the standards related to quality and sustainability issues in addition to the eventual preparation of a practical database.

In this study, the implementation of an integrated approach of BIM, BEM, and BIM-FM tools into LCCA is explored as an intelligent solution, which not only
analyses the required aspects of a building but also simulates future behaviour and provisions. In this regard the development of comprehensive databases are essential to serve as the basis for required future periodic assessments.

Correspondingly, the adoption of the Building Information Modelling to generate relative LCCA databases directly benefits the real investment cost calculation for investors. However, the validity of the BIM databases will be as accurate as the model, thus the wrong modelling process can produce the wrong databases. Therefore, when the modelling process is correct, this integrated solution can assist private and public investors to achieve the goal of promoting the quality, sustainability, and competitiveness of the building stock. This study suggests an accurate data aggregation and series of simulations to provide a more accurate estimation of efficiency and performance of a building, where consequently investors are enabled to know the running cost of a design proposal. In other words, the investor has the possibility to know how much the construction process, environmental performance, and future maintenance of a building will cost, in a transparent workflow.

Bibliography


REP. (n. a.). *Real Estate Investment Appraisal: Some Background Reading*. University of Reading, Department of Real Estate & Planning, Reading.


SIMBIM. (2014). *I'm a BIM Manager, How Can I Help You?* SIMBIM® Solutions, R&D. Barcelona: SIMBIM.

