ENGLISH VERSION..

Economic benefits of LEED certification: a case study of the Centro Ático building

Beneficios económicos de la certificación LEED. Edificio Centro Ático: caso de estudio

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Fecha de Recepción: 30/07/2015
Fecha de Aceptación: 30/12/2015
PAG 139-146

Abstract
This article discusses the economic benefits of the implementation of the sustainable building LEED (Leadership in Energy and Environmental Design) certification in the Centro Ático building located in Bogotá, Colombia. Initially, the consumption of water and electricity are determined, as well as the costs of construction and operation of the building under its original design (built without regard to the parameters set by LEED). Then, strategies to allow the Centro Ático building to obtain the LEED GOLD New Construction V3 2009 certification are proposed and the economic increases associated with them are calculated. Also, the new consumption of water and electricity, when these strategies are applied (modified design), and their operating costs are calculated. Finally, indicators of economic goodness of investment are determined using a cash flow analysis.

Keywords: *LEED, cash flow, IRR, VPN, Payback*

Resumen
En el presente artículo se estudian los beneficios económicos de la aplicación del programa de certificación de construcciones sostenibles LEED, en el Edificio Centro Ático situado en Bogotá - Colombia. Inicialmente, se determinan los consumos de agua y energía eléctrica, y los costos de construcción y operación del edificio bajo su diseño original (construido sin tener en cuenta los parámetros establecidos por LEED). Seguido a esto se plantean estrategias para lograr que el edificio Centro Ático alcance la certificación LEED GOLD New Construction V3 2009 y se calculan los incrementos económicos asociados a éstas. Así mismo, se calculan los nuevos consumos de agua y energía eléctrica bajo la aplicación de dichas estrategias (diseño modificado) y sus correspondientes costos de operación. Finalmente, se determinan los indicadores de bondad económica de la inversión mediante un análisis de flujo de caja.

Palabras clave: *LEED, flujo de caja, TIR, VPN, retorno de la inversión*

1. Introduction

The construction sector is one of the most important for a country's economy, and this is reflected in the country's economic indicators. In Colombia, during the year 2013, the construction industry showed growth of 9.8%, which bolstered GNP growth during that same year (DANE, 2014).

On the other hand, the construction sector is responsible for important environmental impacts due to its high electrical energy, water and raw materials usage; it also generates a large amount of residue and contaminants for the air, soil and water. Therefore this sector has great potential for environmental improvements. Different entities, both public and private, throughout the world have implemented sustainable construction standards in the development of building projects to promote care of the environment and human health.

In the case of the United States, during the mid-90s, the US Green Building Council began work on the first versions of a qualification system for sustainable buildings, which was named LEED (Leadership in Energy and Environmental Design) in 1998. The initial objective of this certification was to create a standard that would define the sustainable building, based on three main aspects: environmental, social and economic. This allows rating the sustainability of buildings in an objective and rational way (Kriss, 2014).

Even though the sustainable construction is starting to become an important part of companies that are part of this sector in Colombia, the data of the implementation systems such as LEED (Leadership in Energy and Environmental Design) are not encouraging. According to reports by DANE (2013), between the years 2009 and 2013 there were approximately 49.1 billion m^2 of construction; as a comparison, only 118 projects were registered in the LEED directory for that same period.

The situation explained above carries an evident need to create an incentive in Colombia for the application of sustainable rating systems, not just for the growth in economic terms for the country but also because they make an outstanding contribution caring for the environment.

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As a result, this research uses a case study to evaluate and establish the benefits, in economic terms, which can be generated by the implementation of LEED New Construction V3 2009 certification for a building in Colombia.

2. Description of the case study

The building that is the focus of this research is the Centro Ático building, an institutional building that is located on the campus of the Pontificia Universidad Javeriana (PUJ) in the city of Bogotá - Colombia. This building, which began operations at the end of 2010, has a total built area of approximately 8.370 m^2 distributed in seven floors.

The building's architecture, as shown in Figure 1, combines exposed concrete with a vaneer of royal veta stone and large facades of glass, a flat roof with elements that allow natural light to enter into the building and a small green area.

Figure 1. *Northwestern view of the Centro Ático building*

The inside of the building includes mostly classrooms, used mainly by the Art and Design Departments, and for the creation of visual content for the university. Therefore, it includes television and audio production studios, editing studios and sound studios. The construction and development of all of these spaces position this building as the only center in Latin America that integrates the resource technologies of audio, video and as well as the entertainment technology of information and communication (TIC); these are used for the production of projects for the university community, the country and the region.

It is important to highlight that the Centro Ático building was not created considering the application of sustainability parameters and therefore it did not follow Green building certification programs such as LEED.

3. Methods and results

3.1 LEED evaluation of the original design

The original design of the Centro Ático building refers to the information used to build the building, including the blueprints and their specifications.

In order to understand the scores for a building that was not created under the parameters established for LEED certification, the certification evaluation for LEED New Construction V3 2009 was done for the original building design, and it received a total score of 20 points. Based on guidelines of the US Green Building Council (USGBC), as a result of the sum of points obtained by each of the seven chapters that the certification encompasses, a building can be certified if it obtains a minimum score of 40 points. Therefore, the original design of Centro Ático did not reach any LEED certification levels.

3.1.1 Water and electrical energy usage of the original design

To calculate the water usage, both for the building's original design as well as the corresponding baseline (the baseline is the point of comparison required by LEED to determine the savings in water and electrical energy usage), we took into account the daily usage of each of the plumbing appliances of the building, calculated based on FTEs (Full Time Equivalents) according to the parameters included in "Water use reduction additional guidance" from USGBC (2009). Given this, we determined that the total baseline water usage for a year-long period was 6.351.755 liters, compared to the annual consumption of 6.323.532 liters for the original design. These indicate that a reduction of 0.44% was achieved in annual water usage versus the baseline established for the LEED certification.

In the case of electrical usage, we needed to model for the spaces in the building using Autodesk (Revit, 2014), which mainly considered the architectural characteristics of Centro Ático, such as the main wrap-around and finishes of walls and floors. Once this model was done, it was exported to a gbXML file which included the building's geometry, the actual location and the materials' thermal properties, with the *objective of importing that file to the web software Autodesk Green Building Studio 2011 (GBS) so as to do the corresponding energy simulation.*

The results obtained with that simulation indicate that the annual electrical consumption of the original design, valued at 775.742 kWh, is 0.51% higher in comparison with the corresponding 771.739 kWh of annual electrical energy usage of the building's baseline.

3.1.2 Construction and operational costs of the original design

Together with finalizing the project for 2010, we obtained the building's total construction cost, which included all of the activities related to direct and indirect costs of the project; this information is presented in Table 1.

From the information shown in Table 1, the total construction costs of $21.901.508.449 [COP], using constant values from 2010, for the original Centro Ático building

Also, in line Fuller (2010), the building's operating costs were analyzed for a 30-year life cycle, assuming only the electrical energy and water usage, using values from when the building became operational in 2011. The overall assumptions to conduct this analysis are presented in Table 2.
The analysis of operational costs, based on the overall considerations presented in Table 2, showed that the operational costs of the building for a 30-year life cycle reached $7.296.301.437 [COP], at constant values from the year 2011.

Table 1. *Construction costs for Centro Ático – original design*

Type of Cost	*Value [S Colombian Pesos, or COP]* [a]
Direct	*20.011.950.528*
Indirect	*1.889.557.921*
Total	***21.901.508.449***

[a] The values shown are based on constant 2010 prices

Table 2. *Overall assumptions for the analysis of the operational costs of the original design*

Description	*Value*
Annual water consumption [m^3]	*6.323,5*
Cost of water [$ COP/m^3] [a]	*2.178,9*
Annual electrical energy consumption [kWh]	*775.742*
Electric energy cost [COP/kWh] [b]	*305,5*
Annual cost increase of public services [%]	*2,5*
Average inflation [%] [c]	*2,7*

[a] *Cost of m^3 of water at constant values from the year 2011.*
[b] *Cost of kWh of electrical energy at constant values from the year 2011.*
[c] *Average inflation in Colombia from the years 2010 to 2013.*

3.2 Alternative proposals and associated costs

In order to obtain the increase in the construction costs generated from the implementation of the LEED certification in a building project in Colombia, different types of strategies were proposed that helped the building reach the necessary score to obtain the LEED GOLD certification. This set of alternatives is referred to as the "modified design." The strategies had the objective to fully retain the use of the building, its technical requirements and the architectural concept, and to provide a solution that is economically viable.

To complete the credits covered in the LEED manual, alternative solutions were established for each of its seven chapters. Table 3 and Table 4 present the cost increases inherent in the application of each one of the proposed solutions to obtain LEED GOLD certification of the direct and indirect costs of the project, as compared with what is established in the budget for the building's original design.

The direct costs listed in Table 4 include the cost increases for architectural, hydraulic, electrical and lighting design. Also we took into account the costs associated with the registration of the project, the review of the designs and the construction, and the expediting of the certification and the delivery of the plaque by USGBC, as described by Mercado Alcalá (2012) and USGBC (2011).

Table 3. *Cost increase based on the strategies to obtain the LEED certification of direct costs*

LEED Credit	**Strategy**	**Cost Increase [$ COP] [a]**
SS4.2	Bike parking area and construction of showers and dressing rooms	8.989.139
SS5.1 ; SS7.2 ; WE1 ; RP1	Replacements for hard exterior areas and the gardens that were there, with gardens including native or adapted species	41.396.977
SS6.1 ; WE1 ; ID1 ; RP1	Construction of system to collect surface water	6.510.941
SS6.2	Construction of filter system for surface rain water	1.759.364
SS7.2	Replacement of grey surface concrete slabs with white concrete	10.540.532
SS8.0	Installation of movement and photo sensors, and changing of exterior lighting	3.931.087
PR WE1 ; WE2 ; WE3 ; ID1 ; RP1	Replacement of traditional plumbing fixtures for high efficiency fixtures	32.470.778
PR EA2 ; EA1 ; RP1	Installation of thermal insulation in the external walls and change conventional lighting to LED lights	64.344.881
EA5	Installation of verification system of electrical consumption by subsystems	45.894.440
MR2 ; RP1	Implementation of a plan to manage residue from the construction and RCD demolition	8.622.490
MR4 ; ID1	Choice of suppliers of steel, concrete and glass	0
IEQ1	Installation of meters of CO2 concentration and Pitot tubes	131.061.053
IEQ3.2	Implementation of the plan to manage quality of the inside air prior to occupation	31.626.039
IEQ4.2	Choice of suppliers for paint and epoxies	0
Total		**387.147.721**

[a] *The costs are based on constant values from the year 2010.*

***Table 4.** Cost increase based on the strategies to obtain the LEED certification for indirect costs*

LEED Credit	Strategy	Cost Increase [$ COP] [a]
Chapters SS ; EA ; MR ; IEQ ; ID ; RP	Contracting architectural design	157.705.296
Chapter WE ; ID ; RP	Contracting hydraulic design	1.218.000
PR EA2 ; EA1 ; RP1 ; SS8.0	Contracting electrical and lighting design	5.231.453
PR EA2 ; PR IEQ1	Contracting air conditioning design	0
PR EA1 ; EA3	Contracting commissioning service	94.146.136
PR EA2 ; EA1 ; RP1	Contracting energy simulation service	22.415.750
MR2 ; RP1	Creation of a plan to manage construction and RCD demolition waste	2.241.575
PR IEQ1	Contracting a local study of the exterior air quality	2.420.901
ID2	Contracting the services of a accredited LEED AP professional	16.139.340
All chapters	Registering the Project with USGBC	2.400.000
All chapters	Design review by USGBC	6.604.944
All chapters	Construction review by USGBC	2.201.648
All chapters	Certification and presentation of the plaque by USGBC	800.000
Total		**313.525.043**

[a] *The costs are based on constant values from the year 2010.*

Based on the results presented in Table 3 and Table 4, the total implementation cost of LEED GOLD certification in the Centro Ático building was $700.672.765 [COP], using constant values from 2010, which corresponds to an increase of 3.2% in the building's total budget (see Table 1). This represents an increase of $83.712 [COP]/m^2, composed of $46.254 [COP]/m^2 for direct costs and $37.458 [COP]/m^2 for indirect costs.

3.3 LEED evaluation of the modified design

After the implementation of the strategies proposed in the modifed design, the building's evaluation was conducted again for LEED New Construction V3 2009; this time the building obtained 66 of the 110 possible points. Therefore, in contrast to the original design, had the Centro Ático building been built with the modified design, it would have obtained the LEED GOLD V3 2009 certification.

3.3.1 Consumption of water and electrical energy in the modified design

In the same way as the original design, the water and electrical energy usage levels were calculated for the modified design.

The results indicate that the modified design of the building consumes nearly 3.623.255 liters of water per year, which is 42.70% less compared to the original design that was used in the construction of the building

Likewise, the results obtained after conducting an energy simulation of the modified design indicate that the annual electrical consumption is 533.384 kWh, which represents a savings of 31.24% versus the consumption of the building's original design.

3.3.2 Operating costs of the modified design

In spite of the cost increases caused by the strategies to obtain LEED GOLD certification for the project, important savings were obtained in the building's water and electrical energy usage. Therefore, just as was done with the original design, an analysis was conducted of the building's life cycle to determine the new operating costs of the project associated with those variables. The general considerations for that analysis were the same as for the analysis of the original design, only varying in the annual levels of water and electricity usage levels: 3.623,3 m^3 and 533.384 kWh, respectively.

The results of the this analysis indicated that the operational costs of the building's modified design for a life cycle of 30 years reached $4.970.840.418 [COP], at constant 2011 values.

4. Analysis of the results

4.1 Cash flow analysis

A cash flow analysis was done for the complete life cycle of the building, so as to determine the indicators of economic benefits due to the implementation of LEED certification. For that analysis, we took into account the general considerations presented in Table 5. Given that PUJ is a non-profit organization, we assumed that the cost of capital was equal to the value of inflation.

Tabla 5. Consideraciones generales para el análisis de flujo de caja

Description	***Value***
Building's life cycle [years]	*30*
Investment to obtain LEED GOLD certification [$ COP]	*700.672.765 **
Annual water savings [m^3]	*2.700,2*
Water cost [COP/m^3]	*2.178,9*
Annual savings of electrical energy [kWh]	*242.358*
Cost of electrical energy [$COP/kWh]	*305,5*
Annual increase of cost for public services [%]	*2,5*
Average inflation [%]	*2,7*
Cost of capital for PUJ [%]	*2,7*

** Constant values from the year 2010.*

We assumed that the total annual revenue due to the implementation of the LEED certification was considered to be the sum of the savings obtained by the reduction of water and electrical energy usage, and that those savings would remain constant over the building's 30-year life cycle (Fuller, 2010). Likewise, we assumed that the annual expenditures would be composed of:

- *The value of the investment in year 0.*
- *The debt down payment from when the building becomes operational.*
- *Interest payments based on PUJ's cost of capital*

Also, it assumes that the total annual income would cover the payment of interests and top ay the largest amount of money posible until the debt is paid off due to the investment done in 2010.

Figure 2 presents the cash flows of the investment implemented to obtain the LEED GOLD certification, in line with the parameters mentioned earlier.

Also, Figure 3 presents the cumulative balance of the investment during the life cycle of the building.

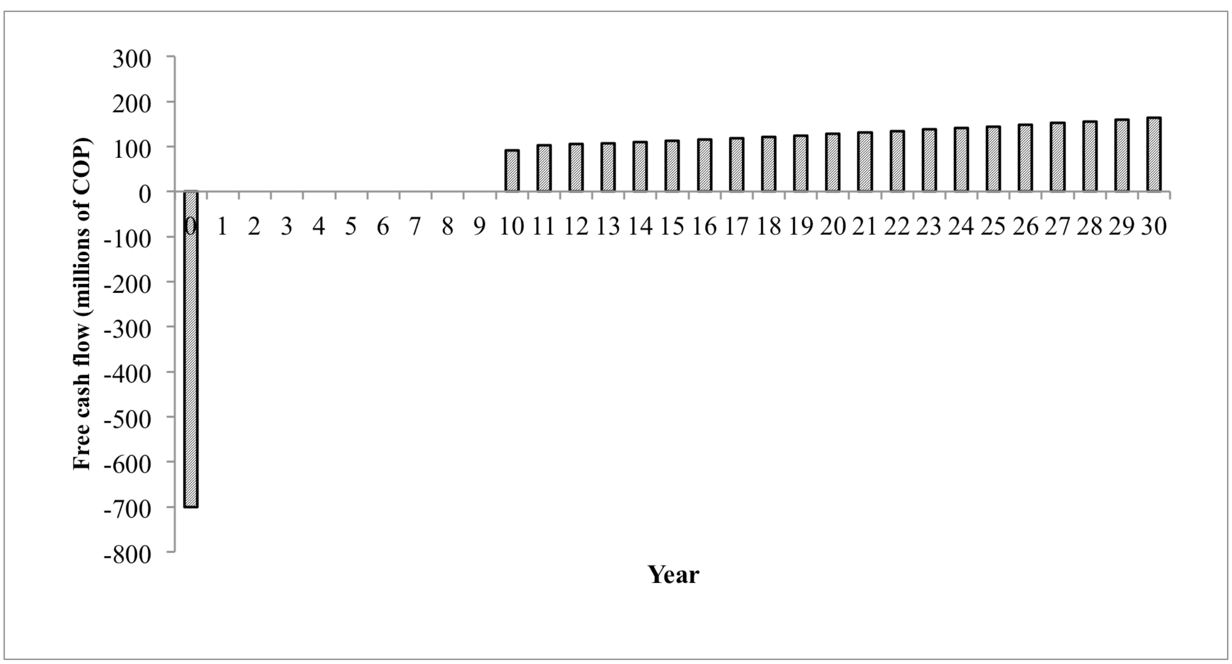

Figure 2. *Investment cash flows to obtain the LEED GOLD certification*

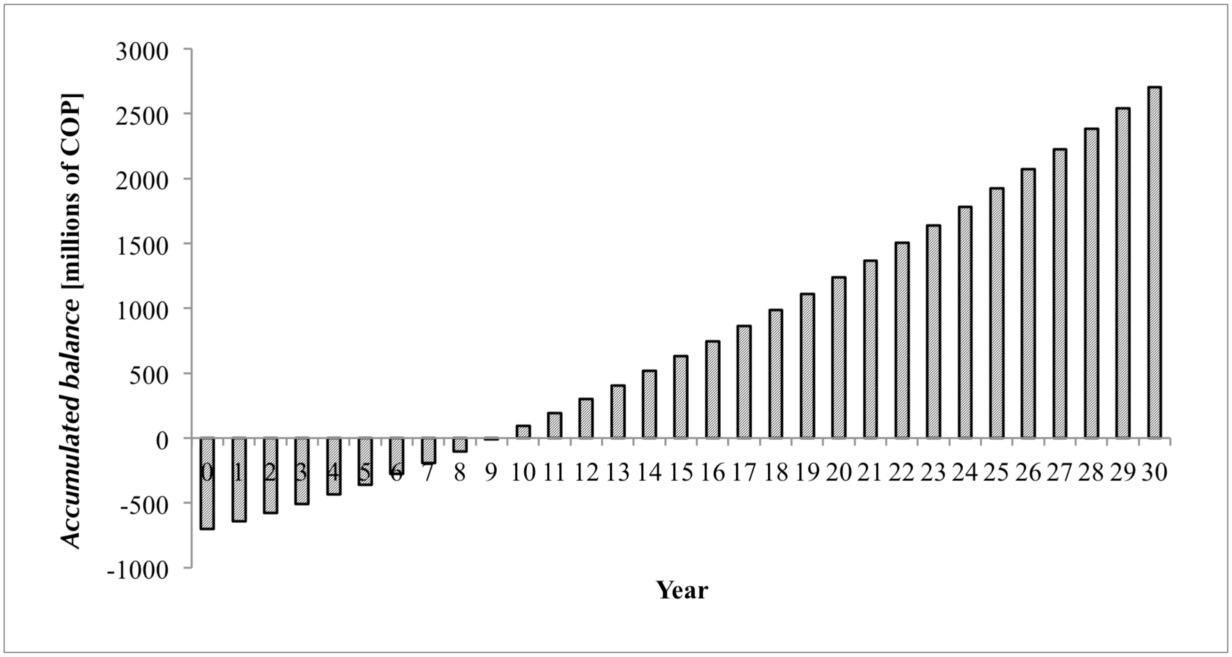

Figure 3. *Accumulated balance of the investment*

4.2 Economic benefit indicators

Taking into account the information presented in Figure 2 and Figure 3, we did a calculation of the economic benefit indicators for the investment; those indicators are presented in Table 6.

According to Table 6, the period required for the Centro Ático building to recuperate the full investment required to obtain the LEED GOLD certification is 10 years; the internal rate of return is 7.1% and the net present value of the building's life cycle is $862.588.146 [COP] at constant 2010 values.

According to González Rodríguez (2011), a larger NPV of the investment is desired; the same value is indifferent and a smaller value is not desirable. Likewise a larger IRR for the cost of capital is recommended, the same is indifferent and a lower one is not recommended.

We take into account that:

- *The investment's IRR of 7.1% is greater than 2.7%, which is PUJ's cost of capital.*
- *The total capital invested, stated in constant 2010 values, was $700.672.765 [COP] and the NPV of the investment was $862.588.146 [COP].*
- *The 10 years it takes to recuperate the investment is acceptable for a 30-year life cycle (Cabas Rosado et al., 2011).*

The cost of implementation of the strategies for the Centro Ático building to obtain the LEED GOLD V3 2009 certification is considered to be a good investment.

Table 6. *Indicators of the investment's economic benefits*

Indicator	***Value***
Internal rate of return (IRR) [%]	*7.10*
Net present value (NPV) [$ COP]	*862,588,146 **
Payback period to recuperate the investment– [years]	*10*

** Constant 2010 pesos*

5. Conclusions

The use of programs for the certification of sustainable buildings, such as LEED, not only lead to sustainability benefits due to the large savings in water and electrical energy consumption, but they also significantly decrease the operational costs during the life cycle of the building.

The investment costs due to the implementation of LEED certification, for the building in this case study, are $700.672.765 [COP], stated at constant 2010 values; as a result they generate a reduction in water and electrical energy usage, with a return of $862.588.146 [COP], at constant 2010 values, over a 30 year life cycle. This investment produces an annual reduction of 42.7% in water usage and 31.2% in electrical energy usage.

Given this, we can state that if strategies for the fulfillment of the requirements in the LEED manual are contemplated during the building's design stage, these may not have important implications in cost increases and on the contrary they may represent usage reductions in the operational phase of the building, which makes the LEED certification a good investment.

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