COMPARATIVE LIFE-CYCLE COST (LCC) STUDY OF GREEN AND TRADITIONAL RESIDENTIAL BUILDINGS: CASE STUDY IN TIRANA, ALBANIA

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IN
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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled "Comparative Life-Cycle Cost (LCC) Study of Green and Traditional Residential Buildings in Tirana, Albania." and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

COMPARATIVE LIFE-CYCLE COST (LCC) STUDY OF GREEN AND TRADITIONAL RESIDENTIAL BUILDINGS: CASE STUDY IN TIRANA, ALBANIA

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This thesis compares the costs of green and traditional residential buildings in Tirana, Albania. Green buildings aim to be more environmentally friendly and energy efficient. However, their economic feasibility is uncertain, especially in places like Tirana where traditional methods are common.

The research looks at existing studies, real-life examples, and cost analysis. We found that while green buildings may cost more to build initially, they often cost less to run and maintain over time compared to traditional ones. Green buildings also have benefits like better air quality and comfort. However, challenges like limited green materials and higher certification costs slow down their adoption.

This study provides evidence on whether green buildings are worth it economically in Tirana. It helps policymakers and builders make better decisions for sustainable construction. It also shows the need for support to overcome obstacles to green building in Tirana and similar places.

Keywords: *Green Buildings, Traditional Buildings, Life Cycle Costs, Sustainability.*

ABSTRAKT

KRAHASIMI I ANALIZES SE KOSTOS TE CIKLIT JETESOR (LCC) I NDERTESAVE RESIDENCIALE TE GJELBRA DHE TRADICIONALE: STUDIM NE TIRANE, SHQIPERI

Ambra Hasku

Master Shkencor, Departamenti i Inxhinierisë së Ndërtimit

Udhëheqësi: Dr. Julinda Keçi

Kjo tezë krahason koston e ndërtimeve të banesave të gjelbra dhe atyre tradicionale në Tiranë, Shqipëri. Ndërtimet te gjelbra synojnë të jenë më miqësore ndaj mjedisit dhe më efikase në përdorimin e energjisë. Megjithatë, kosto e tyre ekonomike është e pasigurt, veçanërisht në vende si Tirana ku metodat tradicionale janë të zakonshme.

Kjo teme shikon studimet ekzistuese, shembujt e jetës reale dhe analizën e kostos. Dolem ne konkluzione se ndërtimet e gjelbra mund të kushtojnë më shumë për tu ndërtuar në fillim, por shpesh kushtojnë më pak për tu operuar dhe për tëu mirëmbajtur në kohën e mëvonshme krahasuar me ato tradicionale. Ndërtimet e gjelbra gjithashtu kanë përfitime si cilësi më të mirë e ajrit dhe komforti. Megjithatë, sfidat si mungesa e materialeve të gjelbra dhe kostoja e lartë e certifikimit ngadalësojnë pranimin e tyre.

Ky studim ofron dëshmi për vlerën ekonomike të ndërtimeve të gjelbra në Tiranë. Ndihmon shtetin, investuesin dhe ndërtuesit të marrin vendime më të mira për ndërtimin e qëndrueshëm. Ai gjithashtu tregon nevojën për mbështetje për të përballuar pengesat ndaj ndërtimit të gjelbër në Tiranë dhe vende të ngjashme.

Fjalët kyçe: Ndërtesat e gjelbra, Analiza e kostos së ciklit jetësor, Ndërtesat tradicionale, i qëndrueshëm/qendrueshmeri.

Dedication

This thesis is dedicated to my parents and my life partner. Thank you! Your endless support and encouragement will never go unnoticed.

I am Forever Grateful!

Acknowledgment

I would like to express my special thanks of gratitude to my advisor Dr. Julinda Keçi, for her guidance and support throughout my Master's journey in Construction Management. Thank you!

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CHAPTER 1

INTRODUCTION

1.1 Introduction:

The construction industry is undergoing a paradigm shift towards sustainability, driven by the imperative to mitigate environmental degradation and enhance resource efficiency. In this context, the adoption of green building practices has emerged as a pivotal strategy to address these challenges. Green buildings, characterized by their use of environmentally friendly materials, energy-efficient designs, and sustainable construction methods, offer promising solutions to reduce the ecological footprint of the built environment. However, while the environmental benefits of green buildings are well-documented, their economic viability remains a subject of debate, particularly in emerging economies like Albania.

Tirana, the capital city of Albania, is witnessing rapid urbanisation and infrastructure development, accompanied by a growing demand for residential and industrial spaces. As the construction sector in Tirana strives to accommodate this demand, there arises a critical need to evaluate the life-cycle costs (LCC) associated with different building typologies. Understanding the economic implications of green building practices is essential for informing policy decisions and fostering sustainable urban development.

Against this backdrop, this thesis presents a comparative analysis of the life-cycle costs of green and traditional residential buildings in Tirana, Albania. By examining the economic performance of these two building typologies over their respective life cycles, this study seeks to provide empirical evidence on the feasibility of green building practices in the context of Tirana's built environment. Through a combination of literature review, case studies, and quantitative analysis, this research aims to elucidate the factors influencing LCC in the realm of green and traditional residential buildings, identify the key cost drivers, and evaluate the long-term economic implications of sustainable construction practices.

The findings of this study are expected to contribute valuable insights to policymakers, urban planners, developers, and investors involved in the construction sector in Tirana and beyond. By shedding light on the economic benefits and challenges associated with green building practices, this research endeavors to facilitate informed decision-making and promote the adoption of sustainable building solutions in Albania's urban development trajectory.

1.2 Thesis Objective:

This thesis aims to conduct a comparative life-cycle cost (LCC) study of green and traditional residential buildings in Tirana, Albania. It will assess the economic performance of green buildings compared to traditional ones, identify factors influencing their life-cycle costs, evaluate environmental benefits of green buildings, and provide empirical evidence for policymakers, urban planners, developers, and investors. The study aims to advance knowledge on sustainable construction practices and support efforts to promote environmentally friendly and economically viable building solutions in Tirana and beyond. The research will also provide insights for policymakers, urban planners, developers, and investors on the economic feasibility and environmental sustainability of green building practices in Tirana.

1.3 Scope of work

The purpose of this thesis is to compare the life-cycle costs (LCC) of conventional and green residential constructions in Tirana, Albania. It will analyse the environmental advantages of green buildings, compare the financial performance of green to regular structures, pinpoint the variables affecting their life-cycle costs, and offer factual data to investors, developers, urban planners, and legislators. The research is to encourage initiatives to promote environmentally friendly and financially feasible building solutions in Tirana and beyond, as well as to expand knowledge on sustainable construction methods. Policymakers, urban planners, developers, and investors will also benefit from the research's insights on the financial viability and environmental sustainability of green construction methods in Tirana.

1.4 Organisation of the thesis

This thesis is divided in 5 chapters. In Chapter 1, the problem statement, thesis objective and scope of works is presented. Chapter 2 includes the literature review. Chapter 3 consists of the methodology followed in this research. In Chapter 4, the case study results are discussed. In Chapter 5, conclusions and recommendations for further research are stated.

CHAPTER 2

LITERATURE REVIEW

Introduction

This literature review aims to provide a comprehensive overview of existing research related to the comparative life-cycle cost (LCC) analysis of green and traditional residential buildings. By synthesizing and analyzing a diverse range of studies, the review seeks to elucidate the economic considerations, environmental benefits, and challenges associated with green building practices, particularly in the context of Tirana, Albania.

Yuan and Lee (2020), in their review study about Life-Cycle Cost Analysis of Green and Conventional Buildings, provided a detailed review of LCC analysis methodologies applied to green and conventional buildings, discussing the economic implications of sustainable building practices. The authors conducted a systematic review of existing literature on LCC analysis for green and conventional buildings, identifying key factors influencing LCC, such as energy savings, maintenance costs, and the lifespan of building components. Their findings indicate that green buildings generally exhibit lower life-cycle costs compared to conventional buildings, primarily due to energy savings and reduced maintenance expenses. The initial higher costs of green building features are often offset by long-term financial benefits. The payback period for green building investments varies depending on factors such as building design, location, and energy prices. The authors also discuss the challenges in conducting LCC analysis, including the variability in methodologies and assumptions used in different studies, emphasizing the need for standardized LCC analysis frameworks to enable more accurate comparisons between green and conventional buildings. This review provides valuable insights into the economic advantages of green buildings over their lifecycle, supporting the argument for adopting sustainable construction practices in Tirana, Albania. The findings justify the inclusion of green building features in residential projects, highlighting their potential for long-term cost savings.

Al-Mohsin and Zuo (2018), in their Economic Evaluation of Green Building Investment, examined various life cycle costing methods used to evaluate the economic performance of green building investments, emphasizing the importance of considering long-term costs and benefits. The methodology employed in this review involved conducting a comprehensive search of academic databases, scholarly journals, and relevant literature sources to identify studies on life cycle cost analysis and life cycle costing methods in the context of green building investments. Keywords such as "green building," "life cycle cost analysis," "life cycle costing," and "economic evaluation" were used to narrow down the search results. The selected studies were then analyzed and synthesized to identify common themes, methodologies, and findings related to the economic evaluation of green building investments. The review revealed a diverse range of methodologies and approaches employed in the economic evaluation of green building investments, including traditional life cycle cost analysis techniques, cost-benefit analysis, net present value analysis, and multi-criteria decision analysis. Studies consistently highlighted the importance of considering life cycle costs, including initial construction costs, operational expenses, maintenance requirements, and end-of-life costs, when assessing the economic viability of green building projects. Additionally, the review identified various factors influencing the economic performance of green building investments, such as energy efficiency, water conservation measures, building lifespan, and regulatory incentives. The findings underscore the significance of life cycle cost analysis and life cycle costing methods in informing decision-making processes related to green building investments. By considering the full life cycle costs and benefits of green building projects, stakeholders can make more informed choices regarding sustainable construction practices.

Gou, Z., Prasad, D., & Yau, Y., (2019) in their Assessing the Economic Viability of Green Buildings: A Cost–Benefit Analysis Approach, presented a cost-benefit analysis framework for assessing the economic viability of green buildings, incorporating environmental and social benefits alongside financial considerations. The methodology employed in this study involved conducting a comprehensive review of existing literature on green building economics, cost-benefit analysis, and related methodologies. Key concepts and frameworks were synthesized to develop a structured approach for assessing the economic viability of green buildings. The cost-benefit analysis framework incorporates both tangible and intangible costs and benefits associated with green building investments, providing a holistic perspective on their economic implications. Their findings highlight the multifaceted nature of the economic benefits and challenges associated with green buildings. Through the cost-benefit analysis approach, various tangible benefits, such as energy savings, operational cost reductions, and enhanced asset value, were identified. Additionally, intangible benefits, including improved indoor air quality, occupant productivity, and environmental stewardship, were recognized as contributing factors to the overall economic value of green buildings. The authors also discuss the implications of the findings for stakeholders involved in green building projects, including policymakers, developers, investors, and building occupants. Key considerations such as the importance of life cycle costing, the role of regulatory incentives, and the valuation of intangible benefits are explored. Moreover, the discussion addresses challenges and limitations associated with the cost-benefit analysis approach and proposes avenues for future research to further refine methodologies and enhance the accuracy of economic evaluations.

This review provides valuable insights into designing effective policies and incentives that promote the adoption of green building practices. Developers and investors can use the insights gained from the cost-benefit analysis approach to assess the financial viability of green building investments and optimize resource allocation. Additionally, building occupants stand to benefit from improved indoor environmental quality and enhanced quality of life in green buildings.

Wang, Q., Shen, Q., & Tang, B., (2017) in their Life-Cycle Cost Analysis of Green Residential Buildings presented the life- cycle costs of green residential buildings in China, comparing them to conventional buildings and assessing the economic feasibility of green building investments. The methodology employed in this study involves a comprehensive analysis of the life-cycle costs associated with green residential buildings. Data collection methods include surveys, interviews, and site visits to gather information on construction costs, operational expenses, maintenance requirements, and energy consumption. The life-cycle cost analysis is conducted using established methodologies to assess the total cost of ownership and compare the economic performance of green buildings to conventional counterparts. The findings of this case study reveal that green residential buildings in China demonstrate favorable economic performance over their life cycle compared to traditional buildings. Through the life-cycle cost analysis, significant cost savings are observed in areas such as energy consumption, maintenance, and operational expenses. Additionally, the study identifies key factors contributing to the economic benefits of green buildings, including energy-efficient design features, renewable energy utilization, and sustainable building materials.

The authors discuss the implications of the findings for stakeholders involved in the construction and development of green residential buildings in China. The economic benefits of green buildings are discussed in the context of environmental sustainability, energy efficiency, and occupant comfort. Furthermore, the discussion addresses challenges and barriers to the widespread adoption of green building practices and proposes strategies to overcome these obstacles.

This reviewed paper offers valuable insights into the methodologies and approaches used to conduct life-cycle cost analysis (LCCA) in the context of green and traditional buildings. I can learn from their methodologies and adapt or refine them to suit the specific requirements of my case study in Tirana.

Gupta, S., Chaudhary, S., & Jain, R., (2019) in their Comparative Life Cycle Cost Analysis of Green and Conventional Buildings in India present the construction industry is grappling with the challenges of rapid urbanization, resource depletion, and environmental degradation, highlighting the need for sustainable building practices. This paper presents a comparative life-cycle cost analysis of green and conventional buildings in India, aiming to assess the economic viability and environmental benefits of sustainable construction practices. By evaluating the life-cycle costs associated with green and conventional buildings, this study seeks to provide insights into the financial feasibility and long-term sustainability of green building investments in the Indian context.

The methodology employed in this study involves a comparative analysis of the life-cycle costs of green and conventional buildings in India. Data collection methods include surveys, interviews, and site visits to gather information on construction costs, operational expenses, maintenance requirements, and energy consumption. The life-cycle cost analysis is conducted using established methodologies to assess the total cost of ownership and compare the economic performance of green buildings to conventional counterparts. The findings of this study reveal that green buildings in

India demonstrate favorable economic performance over their life cycle compared to conventional buildings. Through the life-cycle cost analysis, significant cost savings are observed in areas such as energy consumption, maintenance, and operational expenses. Additionally, the study identifies key factors contributing to the economic benefits of green buildings, including energy-efficient design features, renewable energy utilization, and sustainable building materials. The authors discuss the implications of the findings for stakeholders involved in the construction and development of green buildings in India. The economic benefits of green buildings are discussed in the context of environmental sustainability, energy efficiency, and occupant comfort. Furthermore, the discussion addresses challenges and barriers to the widespread adoption of green building practices and proposes strategies to overcome these obstacles. Understanding the findings and discussions presented in this reviewed paper can help contextualize the research within the broader literature. I can compare and contrast my findings with those of previous studies, identifying similarities, differences, and potential explanations.

In conclusion, the literature on green building practices reveals several key themes. Policymakers play a crucial role in promoting sustainability through effective regulations and incentives. The financial viability of green buildings is a significant concern, with cost-benefit analyses helping developers and investors make informed decisions. Green buildings offer notable environmental and health benefits, including reduced energy consumption and improved indoor air quality. Technological advancements and innovation are essential for enhancing sustainable construction practices. Lastly, successful implementation requires the collaboration of various stakeholders, emphasizing the importance of an integrated approach to developing sustainable built environments.

2.1 Green Building (GB)

Green building practices are increasingly recognized for their potential to reduce environmental impacts, improve energy efficiency, and enhance occupant well-being.

One of the most prominent green building certification programs is the Leadership in Energy and Environmental Design (LEED), which provides a framework for assessing and certifying buildings based on their sustainability performance. This section reviews the key criteria for LEED certification and its implications for green building practices, with a particular focus on the Downtown ONE project in Tirana, which has achieved LEED Gold certification.

LEED certification covers various aspects of building design, construction, operation, and maintenance to promote sustainability and environmental responsibility. The certification criteria are organized into several categories, each addressing specific sustainability goals.

In the category of sustainable site development, LEED encourages selecting sites that minimize environmental impact and promote walkability and public transportation. This includes the protection and restoration of natural habitats and open spaces. Effective stormwater management practices are essential to reduce runoff and pollution, contributing to healthier urban ecosystems.

Water efficiency is another critical criterion for LEED certification. Projects are required to reduce landscape water requirements by at least 50% from the baseline, achieved through efficient plant species selection and irrigation systems, as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool. Additionally, LEED mandates a reduction in aggregate water consumption for fixtures and fittings by 20% from the baseline, ensuring that all new toilets, urinals, lavatory faucets, and showerheads are WaterSense labeled. To support effective water management, LEED requires the installation of permanent water meters for various water subsystems, enabling precise tracking of water consumption and identification of additional savings opportunities.

Energy efficiency is a cornerstone of LEED certification. The program aims to reduce the environmental and economic harms of excessive energy use by ensuring buildings achieve a minimum level of energy efficiency. Whole-building energy simulations must demonstrate at least a 2% improvement over the baseline building performance rating. Moreover, buildings are designed to participate in demand response programs, which enhance energy generation and distribution efficiency, increase grid reliability, and reduce greenhouse gas emissions through load shedding or shifting.

The materials and resources category of LEED certification promotes the use of sustainable and locally sourced materials to reduce the environmental impact associated with material transportation and production. Effective waste management and recycling programs during construction are crucial to minimize waste and promote material reuse. Furthermore, LEED encourages the reuse and recycling of materials during demolition or renovation, further reducing environmental impact.

Indoor environmental quality is another vital aspect of LEED certification. Proper indoor air quality management through ventilation and filtration is essential to maintain a healthy indoor environment. LEED also emphasizes the use of low-emitting materials and finishes to reduce indoor pollutants, contributing to better occupant health. Additionally, providing thermal comfort control and access to daylight and quality views enhances the overall indoor environmental quality.

LEED also includes a category for regional priority, awarding bonus points for addressing specific environmental priorities or concerns in the project's geographic region. This encourages strategies that tackle regional environmental challenges or contribute to regional sustainability goals.

These criteria are structured into different credit categories, and projects earn points by meeting these requirements.

2.2 Characteristics of Selected Buildings

In terms of building characteristics, the shape of the buildings, and type or function are almost similar for both selected buildings. However, the green building were constructed in 2024, while the traditional building were constructed in 2009. Further, in terms of their structure, the selected GB and the traditional one are with concrete structure. Selected Green Building use Green Roof meanwhile the Traditional one use Build up Roof. However, the GB also include concrete decks up to some extent to accommodate the GB technologies such as solar water heating. Considering the building walls, GBs have used low thermal conductive materials with low emissive and heat reflective glasses, while the traditional building used concrete framework and concrete blocks and bricks for the walls. Therefore, GBs have high content of recyclable, regional and environmental friendly materials such as steel, glass and compressed stabilized-earth blocks, whereas the traditional building has more concrete content that have higher embodied carbon.

Overall, it could be considered that the embodied energy consumption and CO2 emissions of the selected buildings could be varied, due to their structural differences.

However, the study excludes the environment cost of the buildings and only considers the initial construction cost, operation, maintenance and end of LCC.

These profile information allow a rational comparison of running costs between GBs and that of traditional buildings.

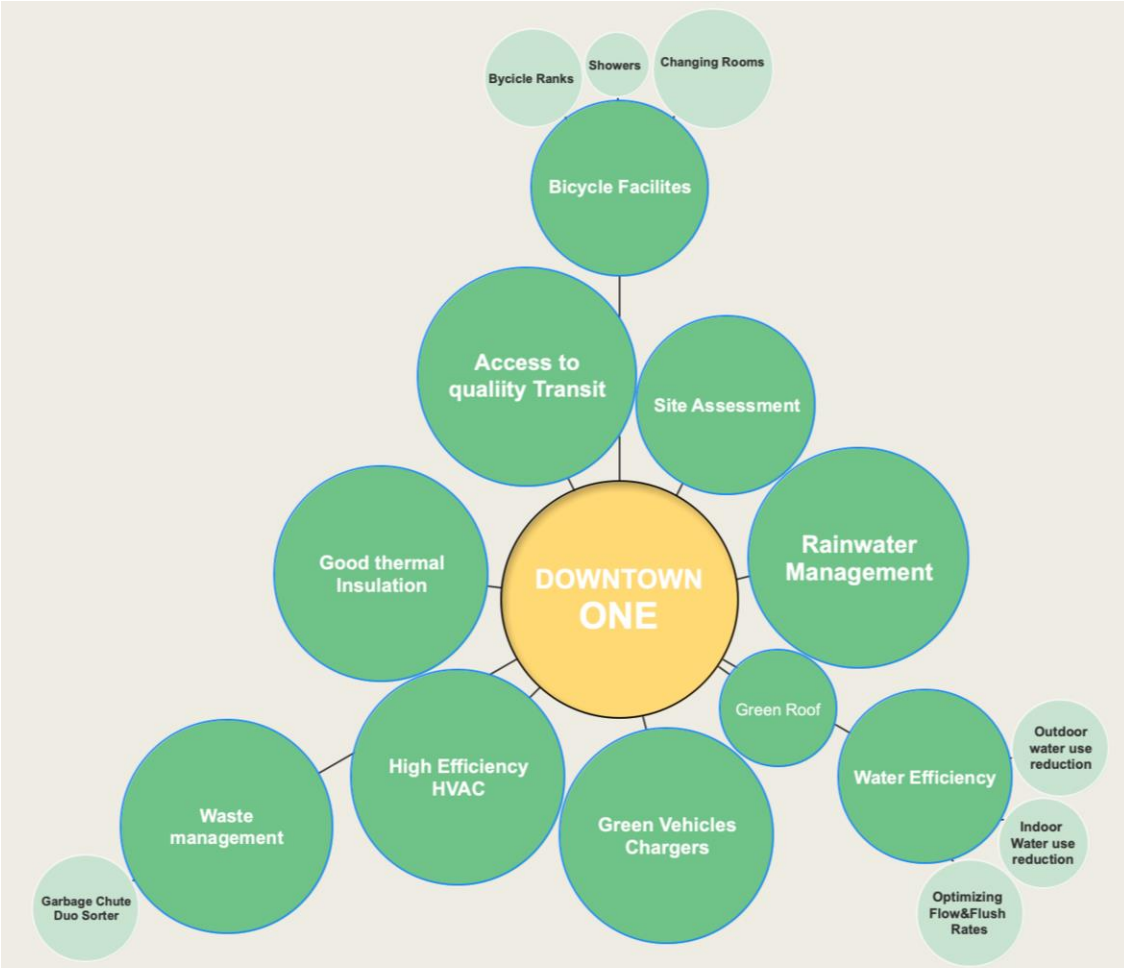
BUILDING		DOWNTOWN ONE	ABA BUSINESS CENTER
Characteristics	Year of construction	2024	2009
	Type of LEED certification	LEED BD + C: NC (v3) Gold	NONE
	No. of floors	40	21
	Shape	Rectangular	Rectangular
	NIA (m2)	50000	30000
	Storey height (m)	3	2,8
	Building height (m)	137,5	65,1
	Type of structure	Concrete frame	Concrete frame
	Roof structure	Flat roof	Flat roof
	Roof material	Green roof on top of concrete Ceiling for green roofs	Concrete Ceiling
	Roof insulation	Vapour Barrier +Insulation board XPS+inclination concrete screed+Bitumen Membrane+ drainage layer+plant substrate+greening	Vapour Barrier +inclination concrete screed+Bitumen Membrane +stone ballast
	Type of wall	Walls with a layer of Polystyrene Forms, steel mesh and concrete and low-e tempered glass windows	Concrete walls+lightened brick walls+ temperd glass and aluminum frames windows
Geography	Orientation	Northeast- Southwest	West-East
Performance	Building occupancy profiles	24h	24h
	Maintenance cycle & Cleaning cycle	Scheduled	Scheduled
	Water consumption (€ per month)	1.500	900
	Electricity consumption (kWh per month)	35.000	45.000

Table 1 Profile of selected green and traditional buildings

2.3 Green technologies implemented in the selected green building

Downtown One GB (Green Building) is designed to display multiple green features like high-efficiency HVAC (Heat Ventilation & Air Conditioning) and lighting system, good thermal insulation, above-average volumes of fresh air for the occupants, bicycle racks, shower and changing rooms positioned close to the bicycle racks and electrical car charges in each of the underground parking floors. The project aims also to prevent water use by optimizing flow and flush rates and cooling towers cycles.

Fig. 1 Green technologies implemented in the selected building diagram



3.4 Data Collection

Data was gathered from professional groups in the two selected buildings through case studies and interviews. Site visits to these buildings were conducted to facilitate interviews and make additional observations. During these site visits, both quantitative and qualitative data were collected.

Quantitative data collection methods are ways of gathering data in a structured and numerical form. These methods involve collecting data that can be measured and analysed statistically to obtain numerical insights and conclusions.

Qualitative data collection Qualitative data refers to non-numerical information that describes qualities, characteristics, or phenomena. It often involves detailed descriptions, themes, and patterns that help understand experiences, behaviors, or interactions. This type of data is typically collected through methods such as interviews, focus groups, observations, and open-ended survey questions. Qualitative data provides insights into the "why" and "how" of a particular issue, offering depth and context that complements quantitative data.

For “Construction Cost” the documents required are the BOQ (Bill of Quantities) and the LEED Certification Documents. These Documents are secured from the source (the investor and Construction Company)

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the research methodology for conducting a Life Cycle Cost Analysis (LCCA) of green buildings will be comprehensively discussed. The focus is on understanding the relationship between the initial cost of building features and their costs over the entire life cycle, without delving into the specific design and implementation details of any particular construction project. The study opts for a direct approach to LCCA, which involves classifying the relationship between the first cost of building features and costs incurred over many years throughout their life cycle.

The LCCA serves as a decision support tool, particularly valuable in the pre-investment stage, aiding stakeholders in evaluating the economic feasibility and long-term viability of green building projects. It entails examining the cost impact of a green building from its construction phase through to its dismantling and the recycling of materials, encompassing the entire life cycle.

The methodology involves conducting various cost analyses, including construction costs, operating & maintenance costs, and salvage costs per square meter of the building. For the operational & maintenance phase, data collection encompasses several key items such as energy consumption invoices, water usage, sewage disposal, and other relevant operational expenses on an annual basis.

Through this detailed research methodology, a comprehensive understanding of the life cycle cost implications of green buildings can be obtained, aiding decision-makers in making informed choices regarding sustainable construction investments.

3.2 Case Study Description

The Buildings which are taken into study in this research thesis are "**DOWNTOWN ONE**" Green Building and "**ABA BUSINESS CENTER**" Conventional Building.

The description of each building is as below.

- **DOWNTOWN ONE**

Downtown One is a skyscraper located in the Central Business District of Tirana and near the city center. Downtown One is the first building in Albania to receive a LEED Gold certification from the USA. The architectural design of Downtown One was created by the world-renowned architectural firm MVRDV. The most striking feature of its architecture is the engraving of the map of Albania in the heart of the facade, along with the interweaving of balconies and loggias. The construction and HVAC project was developed by the globally acclaimed studio ARUP.

Downtown One is the tallest building in Albania, with a height of 150 meters and 40 floors, comprising apartments, offices, commercial spaces, and 5 floors of underground parking. It is set to become a prominent example in Albania of how to maintain an environmentally conscious, pleasant, comfortable, and healthy destination where people can live, work, and shop.

Fig 2 Downtown One Green Building

- **ABA BUSINESS CENTER**

The ABA Business Center was the tallest building constructed in Albania. Opened in 2009 and covering an area of 30,000 square meters, it is located in one of the prime areas in Tirana for businesses and individuals. The glass-walled floors offer spectacular views of the city.

Situated near the “Air Albania” National Stadium, the ABA Business Center provides offices and apartments for rent to businesses and individuals, as well as shops and entertainment venues. This modern building offers various services and facilities, such as 24-hour security, underground parking, a control system, a central infrastructure network for electronic communications, and a central television system.

From the 5th to the 17th floor, modern offices are available, providing all the necessary services for the development of daily business activities. More than 15 companies and associations have their headquarters in this center.

Fig 3 ABA Business Center

Fig 4 Buildings Locations

3.3 Life Cycle Phases of Cost Analyses:

In a Life Cycle Cost Analysis (LCCA), the examination of costs typically spans the various stages of a building or infrastructure project's existence, from inception to disposal. These phases encompass the full lifecycle of the asset and include the following key stages: Firstly, during the Construction and Design Phase, expenses are incurred in the planning, design, and construction processes. Then, in the Operational Phase, ongoing costs related to the day-to-day operation of the asset, such as utilities, maintenance, and security, are considered. Subsequently, the Maintenance Phase involves expenses associated with ensuring the asset's upkeep and functionality over time. Renovation or Retrofitting phases address costs incurred to upgrade or modify the asset. The Dismantling and Disposal Phase accounts for the expenses of decommissioning and disposing of the asset at the end of its useful life. Finally, the Salvage or Resale Phase may involve recouping some costs through the sale of salvageable materials or components post-dismantling. These phases collectively provide a comprehensive framework for evaluating the total cost of ownership of a building or infrastructure asset throughout its lifecycle.

3.4 Costs Included in LCCA:

In Life Cycle Cost Analysis (LCCA), various costs are considered to assess the total cost of ownership of a project or asset over its entire lifespan. These costs typically include:

Initial Costs that are the upfront expenses incurred at the beginning of the project or asset acquisition, such as design, construction, purchase, and installation costs.

Operating Costs that are the ongoing expenses associated with the day-to-day operation of the project or asset. This may include utilities, maintenance, repairs, labor, energy consumption, and any other costs incurred during regular operations.

Maintenance Costs that include the costs associated with maintaining and preserving the functionality of the project or asset over time. Maintenance costs cover activities such as cleaning, servicing, repairs, and replacements of components or systems.

Residual Values are the estimated salvage or resale values of the project or asset at the end of its useful life. Residual values represent any remaining monetary worth that can be recouped through the sale of reusable materials or components.

By considering these various costs throughout the life cycle of the project or asset, LCCA provides a comprehensive analysis of the total cost of ownership, helping decision-makers evaluate the economic viability and sustainability of different options.

3.5 Building Service Life

The building service life refers to the duration over which a building remains functional, acceptable, and capable of meeting the minimum performance standards. It encompasses the period during which the building satisfies its intended purpose without significant deterioration or loss of functionality. Factors that influence the service life of a building include the quality of construction materials, design considerations, maintenance practices, environmental conditions, and usage patterns.

In this case study the LCC of buildings was evaluated using Net Present Value (NPV) analysis. Following the guidelines in ISO 15686–5:2008, costs were adjusted for inflation and discounted to the base year. Specifically, inflation at 2.9% based on data from the Bank of Albania. The analysis spanned 50 years for all buildings, with a sensitivity analysis conducted for different timeframes to assess their impact on the results.

3.6 Construction Cost

In Life Cycle Cost Analysis (LCCA), the construction cost refers to the expenses associated with the initial development and construction of a building or infrastructure project. The construction cost is a crucial component of LCCA, as it represents a significant portion of the total investment in the project and influences the overall life cycle cost. In this case study, Downtown One frame structure Green Building, with a gross area of 57050 m2 is completed in construction period of 2019 to 2024. Based on the Downtown One BOQ the cost of construction for square meter is 1200€.

On the other hand the ABA Business Center Traditional Building, with a gross area of 30000 m2 is completed in the year 2009. Based on the BOQ the construction cost for square meter was 600€.

But since the construction periods are different, to calculate the construction cost of the building in 2024, we need to account for inflation over the 15-year period from 2009 to 2024. We can use the formula for future value with inflation:

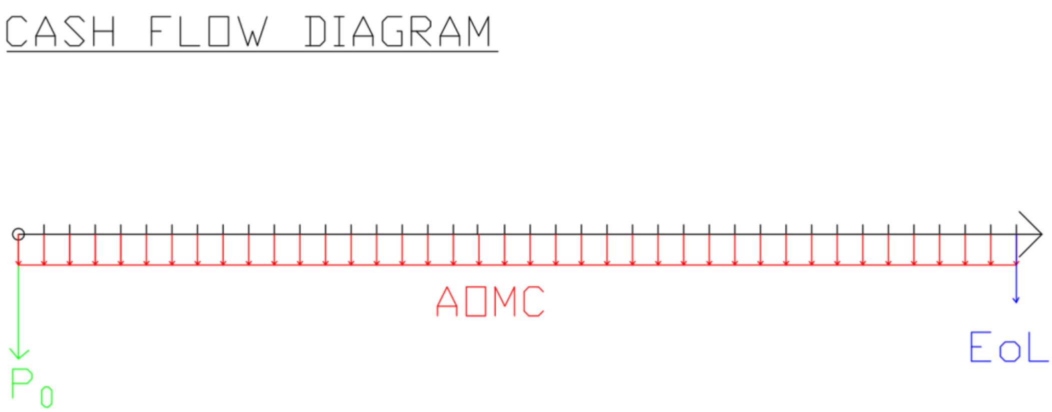


Fig. 5 Cash Flow Diagram

Future Value = Present Value x (1+ Inflation Rate)^n

Where:

- Present Value is the construction cost in 2009 (600€)

- Inflation rate is the annual inflation rate (expressed as a decimal)
- n is the number of years (15 years)

- To proceed we need an average inflation rate form year 2009 to 2024 in Albania from INSTAT. Which is 2.63% as you can see in Fig 1.4.

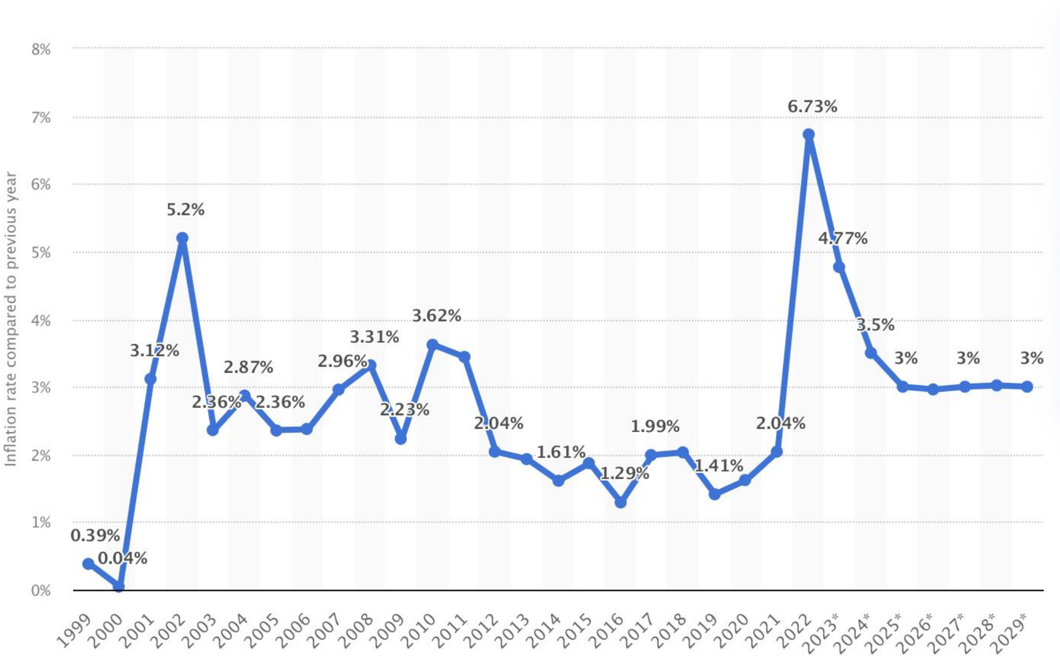


Fig 6 Albania: Inflation rate from 1999 to 2029

Future Value = 600 x $(1+0.0263)^{15}$

Future Value = 600 x $(1.0263)^{15}$

Calculating the exponentiation:

$(1.0263)^{15}$ = 600 x $(1+0.0263)^{15}$

$(1.0263)^{15}$ = 600 x $(1.0263)^{15}$

$(1.0263)^{15} \approx 1.485947$

Now, multiplying this by the present value:

Future Value ≈ 600 x 1.485947

Future Value ≈ 891.57 €

3.7 Building Operating & Maintenance Cost

Building operation and maintenance costs refer to the expenses incurred for the ongoing operation, upkeep, and preservation of a building throughout its lifespan. These costs encompass a wide range of activities and services necessary to maintain the building's functionality, safety, and aesthetics. Examples of building operation and maintenance costs include:

1. Utilities: Expenses related to electricity, water, gas, heating, and cooling needed to operate the building's systems and provide essential services to occupants.

2. Maintenance and Repairs: Costs associated with routine maintenance, preventive maintenance, and repairs of building components, systems, and equipment. This includes tasks such as HVAC servicing, plumbing repairs, roof maintenance, and painting.

3. Cleaning and Janitorial Services: Costs for cleaning and maintaining the cleanliness of the building's interior and exterior spaces, including floors, windows, restrooms, and common areas.

4. Landscaping and Groundskeeping: Expenses for landscaping, lawn care, and maintaining outdoor areas such as gardens, walkways, parking lots, and courtyards.

5. Security: Costs for security personnel, surveillance systems, access control measures, and other security measures to ensure the safety and security of occupants and property.

6. Property Management Fees: Fees paid to property management companies for overseeing the day-to-day operations of the building, including tenant relations, lease management, and financial administration.

7. Taxes and Regulatory Fees: Property taxes, licensing fees, and other regulatory costs imposed by local authorities or government agencies.

Calculating the operation and maintenance (O&M) cost of a building involves several steps, incorporating various cost elements. Here's a detailed guide on how to approach this calculation:

3.7.1 Identify Cost Elements

Operation Costs:

- Utilities: Energy (electricity, gas), water, and other utilities.
- Janitorial Services: Cleaning supplies, labor costs.
- Security Services: Security personnel, surveillance systems.
- Waste Management: Regular garbage disposal, recycling services.
- Administrative Costs: Office supplies, management fees, etc.

Maintenance Costs:

- Preventive Maintenance: Regular inspections, servicing of HVAC systems, elevators, fire alarms, etc.
- Corrective Maintenance: Repairs needed due to wear and tear or unexpected issues.
- Landscaping: Upkeep of gardens, lawns, and other outdoor spaces.
- Building Repairs: Structural repairs, painting, roofing, etc.
- Replacement Costs: Costs associated with replacing major components over time (e.g., HVAC systems, roofing).

3.7.2 Data Collection

I have gathered historical data and estimates for the above cost elements. These were obtained from historical financial records and quotes from service providers.

Referring to "Fuller, S. K., & Petersen, S. R. (1996). Life-Cycle Costing Manual for the Federal Energy Management Program. NIST Handbook 135. National Institute of Standards and Technology", a 40-year analysis period is standard practice in LCC analysis for buildings due to the typical lifespan of major building components and systems.

3.7.3 Calculate Individual Costs

Utilities: Energy Consumption and Cost

When analyzing the energy consumption and costs of traditional buildings, it's essential to consider several factors, including total kWh consumption, cost per kWh,, and building usage patterns. Here's a detailed overview:

Total kWh Consumption

The total kWh consumption in buildings is determined by the sum of all electrical appliances, lighting, heating, cooling, and other energy-consuming devices. This method provides a baseline for understanding overall energy usage, considering every device's power rating and usage duration.

Cost per kWh

The cost per kWh can vary depending on the region, energy provider, and time of year. To estimate annual energy costs, we use an average cost per kWh.

-Water:

To calculate the cost of water usage, multiply the total cubic meters of water consumed by the cost per cubic meter. This includes all water used for daily operations, landscaping, and any other water-dependent activities. Seasonal variations should be considered, as water usage might increase during dry seasons for irrigation purposes or decrease during rainy seasons.

Janitorial Services are calculated from labor costs (number of janitors x hourly wage x hours per week) including also the costs for cleaning supplies and equipment.

Security Services include costs for security personnel (number of guards x hourly wage x hours per week) and maintenance and monitoring costs for surveillance systems.

Waste Management include regular garbage collection fees and costs for recycling services.

Preventive and Corrective Maintenance:

Preventive maintenance include scheduled services (e.g., quarterly HVAC checkups) and also contractual costs with service providers. While Corrective maintenance if found from historical data on average repair costs per year and estimates for unexpected repairs.

Landscaping:

Landscaping includes labor and materials for regular upkeep, seasonal plantings, fertilizing, and irrigation costs.

3.7.4 Aggregate Costs

Summarize all individual costs to obtain the total O&M cost. This can be broken down into monthly, quarterly, or annual costs, depending on the granularity needed.

3.7.5 Apply Adjustments

Adjust the costs for inflation or other economic factors if you're projecting future costs. Use historical inflation rates or specific industry forecasts.

In our Case Study the calculations are as below:

The operation and maintenance (O&M) cost for a traditional building. We'll break down the costs into various components as previously described.

ABA BUSINESS CENTER

The size of this building is 30,000 square meter, with a location in an urban area with average utility costs.

Operation Costs

From all the interviews with the O&M staff of Aba BC, we have the information that this building has a total energy consumption of 45,000 kWh/month at €0.12/kWh, and a total volume of 900 cubic meters/month at €3/cubic meter. There are 9 janitors that are payed €15/hour and work 160 hours/month each and the cost for cleaning supply is nearly €900/month. For the Security Services there are 6 guards employed, that are paid €20/hour for 160 hours/month each. Also the cost for surveillance system maintenance is €900/month. As per waste management, the garbage disposal costs €1200/month and recycling costs €450/month

Maintenance Costs

Heat and Ventilation Air Conditioning service for this building costs €800/quarter (average €267/month). Elevator maintenance is €1200/month

And also a very important information is about Corrective Maintenance that has a historical average of €700/month. Costs of Landscaping include a weekly service of €1000/month. Building Repairs and Replacements have an annual budget of €15,000/year (average €1,250/month).

All the information about "ABA Business Center” above will be calculated as below.

Summary of Monthly Costs

- Utilities: €5,400 (energy) + €2,700 (water) = €8,100
- Janitorial Services: €21,600 (labor) + €900 (supplies) = €22,500
- Security Services: €19,200 (labor) + €900 (surveillance) = €20,100
- Waste Management: €1,200 (garbage) + €450 (recycling) = €1,650
- Preventive Maintenance: €267 (HVAC) + €1,200 (elevator) = €1,467
- Corrective Maintenance: €700
- Landscaping: €1,000
- Repairs and Replacements: €1,250

Total O&M Cost Per Month

Adding up all these costs, the total monthly operation and maintenance cost for the traditional building is:

€8,100 + €2,500 + €20,100 + €1,650 + €1,467 + €700 + €1,000 + €1,250 = €56,767

Conclusion

The total monthly operation and maintenance cost for this traditional residential/office building is €56,767 or €1.9/m^2. This includes all typical O&M expenses, such as utilities, janitorial services, security, waste management, preventive and corrective maintenance, landscaping, and building repairs and replacements.

DOWNTOWN ONE

The size of this green building is slightly bigger than the traditional one with a 50,000 square meters total area. The location of Downtown One is in an urban area with average utility costs just as ABA BC. Unlike the traditional building, Downtown one has some green features like: Solar panels, energy-efficient HVAC system, water-saving fixtures, green roof, and enhanced insulation, garbage chute duo sorter, LEED Gold

Operation Costs

From all the estimates made from the Project Manager and his staff we found out that

The Energy Consumption of this building is estimated to be 35,000 kWh/month with a cost of €0.12/kWh (this is due to energy efficiency and solar panels offsetting some usage). While the water consumption is estimated to be 1,500 cubic meters/month at €3/cubic meter (this is due to water-saving fixtures and rainwater harvesting). This building will need 15 janitors at €15/hour, for 160 hours/month each. And also cleaning supplies cost at €3000/month. For security services the building will need 10 guards at a cost of €20/hour for 160 hours/month each, and surveillance system maintenance is estimated as €1,500/month. As per waste management it is estimated that the garbage disposal would be €1,500/month since garbage chute with compression is installed and also recycling these garbage will cost €750/month.

Maintenance Costs

HVAC service for Downtown One building is expected to be €3000/quarter (average €835/month, assuming less wear due to energy efficiency). Elevator maintenance will be likely €2,000/month and it is added the cost of green roof maintenance that is €200/month, also solar panel maintenance cost of €150/month

Historical average of corrective maintenance is estimated to be €500/month (this is assumed lower due to higher quality and durability of green building materials)

Landscaping is estimated to have a weekly service: €1,000/month (same as traditional, assuming similar outdoor space). Building Repairs and Replacements is estimated to have an annual budget: €12,000/year (average €1,000/month, potentially lower due to durability and lower wear).

All of the information above will be used to calculate an Operation and Maintenance Total Cost for Downtown One.

Summary of Monthly Costs

- Utilities: €4,800 (energy) + €1,500 (water) = €6,300

- Janitorial Services: €36,000 (labor) + €3,000 (supplies) = €39,000

- Security Services: €32,000 (labor) + €1,500 (surveillance) = €33,500

- Waste Management: €1,500 (garbage) + €750 (recycling) = €2,250

- Preventive Maintenance: €835 (HVAC) + €2,000 (elevator) + €200 (green roof) + €150 (solar panel) = €3,185

- Corrective Maintenance: €500

- Landscaping: €1,000

Downtown ONE		ABA BC	
Year	Annual Cost	Year	Annual Cost
2024	1.040.820,0 €	2024	681.204,0 €
2025	1.072.044,6 €	2025	701.640,1 €
2026	1.104.205,9 €	2026	722.689,3 €
2027	1.137.332,1 €	2027	744.370,0 €
2028	1.171.452,1 €	2028	766.701,1 €
2029	1.206.595,6 €	2029	789.702,1 €
2030	1.242.793,5 €	2030	813.393,2 €
2031	1.280.077,3 €	2031	837.795,0 €
2032	1.318.479,6 €	2032	862.928,8 €
2033	1.358.034,0 €	2033	888.816,7 €
2034	1.398.775,0 €	2034	915.481,2 €
2035	1.440.738,3 €	2035	942.945,6 €
2036	1.483.960,4 €	2036	971.234,0 €
2037	1.528.479,3 €	2037	1.000.371,0 €
2038	1.574.333,6 €	2038	1.030.382,2 €
2039	1.621.563,6 €	2039	1.061.293,6 €
2040	1.670.210,6 €	2040	1.093.132,4 €
2041	1.720.316,9 €	2041	1.125.926,4 €
2042	1.771.926,4 €	2042	1.159.704,2 €
2043	1.825.084,2 €	2043	1.194.495,3 €
2044	1.879.836,7 €	2044	1.230.330,2 €
2045	1.936.231,8 €	2045	1.267.240,1 €
2046	1.994.318,8 €	2046	1.305.257,3 €
2047	2.054.148,3 €	2047	1.344.415,0 €
2048	2.115.772,8 €	2048	1.384.747,5 €
2049	2.179.245,9 €	2049	1.426.289,9 €
2050	2.244.623,3 €	2050	1.469.078,6 €
2051	2.311.962,0 €	2051	1.513.151,0 €
2052	2.381.320,9 €	2052	1.558.545,5 €
2053	2.452.760,5 €	2053	1.605.301,8 €
2054	2.526.343,3 €	2054	1.653.460,9 €
2055	2.602.133,6 €	2055	1.703.064,7 €
2056	2.680.197,6 €	2056	1.754.156,7 €
2057	2.760.603,6 €	2057	1.806.781,4 €
2058	2.843.421,7 €	2058	1.860.984,8 €
2059	2.928.724,3 €	2059	1.916.814,4 €
2060	3.016.586,0 €	2060	1.974.318,8 €
2061	3.107.083,6 €	2061	2.033.548,4 €
2062	3.200.296,1 €	2062	2.094.554,8 €
2063	3.296.305,0 €	2063	2.157.391,4 €
2064	3.395.194,2 €	2064	2.222.113,2 €
TOTAL	**81.874.333,3 €**	**TOTAL**	**53.585.752,9 €**
Avarage	**1.996.935,0 €**	**Avarage**	**1.306.969,6 €**

Table 2 Comparative O&M Costs of GB vs. Traditional Buildings in 40 years

Repairs and Replacements: €1,000

Month

Adding up all these costs, the total monthly operation and maintenance cost for the green building is:

€41,500 + €39,000 + €33,500 + €2,250 + €3,185 + €500 + €1,000 + €1,000 = €86,735

Conclusion

The total monthly operation and maintenance cost for this green office building is $86,735 or €1.7/m^2. This includes all typical O&M expenses, adjusted for the efficiencies and additional maintenance associated with green technologies.

O&M Costs		
	Downtown ONE	**ABA Business Center**
Type of Building	**GB**	**CB**
Utilities	6.300,00 €	€ 8.100,00
Janitorial Services	39.000,00 €	€ 22.500,00
Security Services	33.500,00 €	€ 20.100,00
Waste Management	2.250,00 €	€ 1.650,00
Preventive Maintenance	3.185,00 €	€ 1.467,00
Corrective Maintenance	500,00 €	€ 700,00
Landscaping	1.000,00 €	€ 1.000,00
Repairs & Replacements	1.000,00 €	€ 1.250,00
TOTAL	**€ 86.735,00**	**€ 56.767,00**
Total/m2	**€ 1,73**	**€ 1,89**

Table 3 Comparison of O&M Cost per square meter

3.7 End of Life Cost

End-of-life costs refer to the expenses incurred when a building, asset, or product reaches the end of its useful life. Calculating the End of Life (EOL) cost of a residential building involves estimating all the expenses associated with the decommissioning, demolition, and disposal of the building at the end of its useful life. This typically includes costs for: Decommissioning which includes shutting down and making the building safe before demolition, Demolition which includes physically tearing down the building, Disposal that is made by removing and properly disposing of waste materials. Site Restoration:which includes restoring the site to a specific condition after demolition.

To perform this calculation, we follow these steps:

1. Estimate Decommissioning Costs

Decommissioning involves shutting down building systems, removing hazardous materials, and preparing the building for demolition.

2. Estimate Demolition Costs

Consider factors such as the size and type of building, materials used, and local labor costs.

3. Estimate Disposal Costs

This includes the cost of transporting and disposing of materials. Costs can vary based on the material types (e.g., concrete, wood, metals) and local disposal fees.

4. Estimate Site Restoration Costs

This includes costs to remove any remaining debris, grading the site, and potentially planting grass or trees.

5. Factor in Salvage and Recycling Revenue

If some materials can be salvaged or recycled, you can offset some of the costs with the revenue from these materials.

6. Account for InflationIf the demolition and disposal will occur many years in the future, we will adjust costs for inflation.

Calculations made for ABA Business Center

- Decommissioning: €10,000

- Demolition: €50,000

- Disposal: €30,000

- Site Restoration: €15,000

- Legal/Regulatory: €5,000

- Salvage/Recycling Revenue : €-5,000 (negative because it offsets costs)

The total End of Life cost would be:

Total EOL Cost = Decommissioning + Demolition +Disposal + Site Restoration + Legal/Regulatory - Salvage/Recycling Revenue

Total EOL Cost = 10,000 + 50,000 + 30,000 + 15,000 + 5,000 - 5,000

Total EOL Cost = 105,000

So, the End of Life cost of ABA BC would be €105,000.

Calculations made for Downtown One

1. Decommissioning: €15,000 (more thorough due to green features and materials)
2. Demolition: €60,000 (higher due to specialized materials and techniques)
3. Disposal: €25,000 (special disposal for eco-friendly materials)
4. Site Restoration: €20,000 (restoring to green standards)
5. Legal/Regulatory: €7,000 (additional compliance for green certifications)
6. Salvage/Recycling Revenue: €-20,000 (significant offset due to high-value recyclable materials)

Total Present EOL Cost= 15,000 + 60,000 + 25,000 + 20,000 + 7,000 - 20,000

Total Present EOL Cost = 107,000

3.8 Comprehensive Net Present Worth Analysis

Calculating the net present worth (NPW) of a project involves considering all costs associated with the project, discounted to their present values. This analysis helps in understanding the total cost of the project in today's terms, accounting for the time value of money. Here, we will calculate the NPW for both project with their specific costs and a discount rate same as the average inflation for the period of years 2024-2064

Downtown One Project Details:

With an initial Cost of €60,000,000 as mentioned above, an annual operating and maintenance cost of €1,040,820 for a period of 40 years and an end-of-life cost (of about €107,000 at the end of 40 years. Given a discount rate , same as the average inflation of this period 3% (0.03). We will calculate the Net Present Worth.

Firstly, the Present Value of Initial Cost is simply the cost itself. Since it is an upfront expenditure. So for Downtown One $PV_{initial} = C_0 =$ €60,000,000 The annual operating costs represent a series of equal payments over 40 years, which can be calculated using the present value of an annuity formula:

$PV_{annual} = C \text{ X } (1 - (1 + r)^{-n}/r)$ Substituting the previously calculated values:

$PV_{annual} = 1{,}040{,}820 \text{ X } (1 - (1 + 0.03)^{-40})/0.03)$

After calculating this equation we get the present value of the annual costs, that is

$PV_{annual} \approx 24{,}065{,}170.53$€

The end-of-life cost represents a single payment to be made at the conclusion of the 40-year period. However, given that we have already discounted this cost to its present value, its impact has been appropriately accounted for in the overall net present worth calculation. $PV_{end} = 107{,}000$€

To determine the net present worth (NPW) of the project, all the present values calculated previously must be combined. This includes the present value of the initial cost, the present value of the annual operating costs, and the present value of the end-of-life cost. Summing these present values provides the total financial impact of the project in today's monetary terms.

$NPW = 60{,}000{,}000 + 24{,}065{,}170.53 + 107{,}000 \approx 84{,}172{,}171$€

In conclusion the net present worth (NPW) of this project, considering an initial cost of €60,000,000, annual operating costs of €1,040,820 over 40 years, and an end-of-life cost of €107,000, discounted at a rate of 3%, is approximately €84,172,171.

ABA Business Center Project Details:

With an initial Cost of €26,747,100 as mentioned above, an annual operating and maintenance cost of €681,204 for a period of 40 years and an end-of-life cost (of about €105,000 at the end of 40 years. Given a discount rate , same as the average inflation of this period 3% (0.03). We will calculate the Net Present Worth for this traditional building.

The initial cost is an upfront expenditure, so its present value is simply the cost itself,

$PV_{initial} = C_0 = €26,747,100$

The present value of a series of equal annual payments (annuity) is calculated using the following formula:

$PV_{annual} = C \times (1 - (1 + r)^{-n}/r)$ Substituting the previously calculated values

Where:

- C is the annual cost (€681,204)
- r is the discount rate (0.03)
- n is the number of years (40)

After completing all the calculations, the resultant value is obtained, $PV_{annual} \approx 15,743,713.73€$

Just like previously calculated, the end of life cost is already at its present value, $PV_{end} = 105,000€$

And lastly to determine the net present worth of the project, all the present values calculated previously must be combined. This includes the present value of the initial cost, the present value of the annual operating costs, and the present value of the end-of-life cost:

$NPW = 26,747,100 + 15,743,713.73 + 105,000 \approx 42,595,813.73$ €

The net present worth (NPW) of this project, which includes an initial cost of €26,747,100, annual operating costs of €681,204 over 40 years, and an end-of-life cost of €105,000, discounted at a rate of 3%, is approximately €42,595,813.73.

END OF LIFE COST		
	Downtown ONE	**ABA Business Center**
Type of Building	**GB**	**CB**
Decommissioning	€ 15.000,00	€ 10.000,00
Demolition	€ 60.000,00	€ 50.000,00
Disposal	€ 25.000,00	€ 30.000,00
Site Restoration	€ 20.000,00	€ 15.000,00
Legal/Regulatory	€ 7.000,00	€ 5.000,00
Salvage Value	-€ 20.000,00	-€ 5.000,00
TOTAL	**€ 107.000,00**	**€ 105.000,00**
Total/m2	**€ 2,14**	**€ 3,50**

Table 4 Comparison of End of Life Costs per square meter

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter presents and discusses the findings from the Net Present Worth (NPW) analysis conducted for both green and traditional buildings. The analysis includes an initial capital expenditure, recurring annual costs, and a one-time end-of-life cost, all discounted to their present values. The results provide a comprehensive understanding of the financial viability and long-term cost implications of green versus traditional building practices.

The analysis yielded the following present value life cycle costs:

- Green Building Present Value Life Cycle Cost: €1,683/m2
- Traditional Building Present Value Life Cycle Cost: €1,420/m2

These figures represent the total discounted costs over the lifespan of the buildings, taking into account initial construction costs, annual operating expenses, maintenance costs, and end-of-life costs.

Green buildings typically involve higher initial costs due to the use of sustainable materials and technologies. These costs, however, are often offset by lower operating and maintenance expenses over time. In contrast, traditional buildings may have lower upfront costs but can incur higher costs in the long run due to less efficient systems and higher maintenance requirements. On the other hand the annual operating costs for green buildings are generally lower compared to traditional buildings. This is attributed to energy-efficient systems, reduced water usage, and other sustainable practices that reduce overall consumption and utility expenses. The higher present value life cycle cost of green buildings reflects the initial investment, but these costs are mitigated by long-term savings in operational expenditures. Green buildings are designed for durability and efficiency, often resulting in lower maintenance costs and longer lifespans. Additionally, the end-of-life cost, which includes demolition and disposal, is minimized through sustainable practices like recycling and reuse of materials. Traditional buildings, on the other hand, may face higher maintenance and end-of-life costs due to less durable construction materials and less efficient end-of-life management practices. The NPW analysis highlights a critical trade-off between initial investment and long-term savings. Although green buildings have a higher present value life cycle cost (€1,683/m²) compared to traditional buildings (€1,420/m²), the potential for reduced operational and maintenance costs offers significant long-term financial benefits. Stakeholders must consider these factors when making investment decisions, as the higher initial cost of green buildings can lead to substantial savings and environmental benefits over the building's lifespan. Beyond financial considerations, green buildings offer numerous environmental and social advantages, including reduced carbon emissions, improved indoor air quality, and enhanced occupant health and well-being. These benefits contribute to the overall value proposition of green buildings, making them a preferable choice for sustainable development.

Buildings	Downtown One		ABA Bussines Center	
Total Area	50000 m2		30000 m2	
Construction Cost	€	60.000.000,00	€	26.760.000,00
Operation & Maintenance Cost	€	24.065.170,53	€	15.743.713,73
End of Life Cost	€	107.000,00	€	105.000,00
Total	**€**	**84.172.170,53**	**€**	**42.608.713,73**
Total Cost/ m2	**€**	**1.683,44**	**€**	**1.420,29**

Table 5 Summary Table

The NPW analysis demonstrates that while green buildings require a higher initial investment, their long-term financial and environmental benefits outweigh those of traditional buildings. The present value life cycle cost of €1,683/m² for green buildings, compared to €1,420/m² for traditional buildings, reflects this investment in sustainability and efficiency. Stakeholders should weigh these factors carefully, recognizing that green buildings offer not only economic advantages but also significant contributions to sustainability and quality of life.

Investing in green buildings leads to substantial long-term financial gains and environmental benefits.
Green buildings (GBs) cost 19% more than traditional buildings, offering savings of 9% in operation and maintenance, and savings of 39% in end of life cost.

The construction cost makes the most significant portion of the total cost of both buildings. With 71.3% of the total cost in GB and 62.8% in Traditional Building.

GB offer superior economic performance over the long term due to lower maintenance and energy costs. This highlights the importance of considering long-term economic benefits when evaluating building projects.

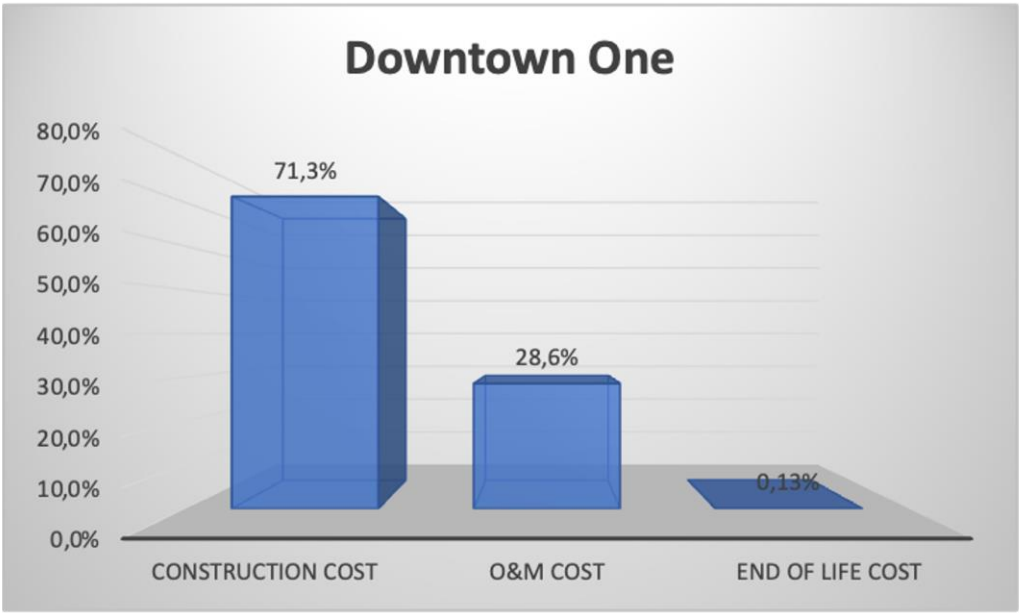


Fig. 7 Visualisation of GB Costs

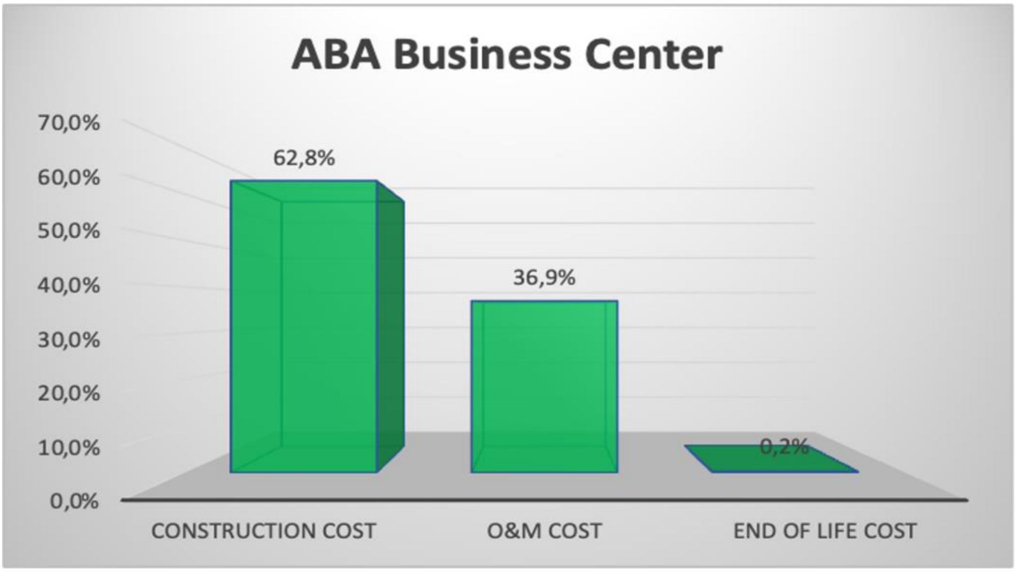


Fig. 8 Visualisation of Traditional Building Costs

CHAPTER 5

CONCLUSION

This study analyzed the LCCA of both green and traditional buildings, incorporating initial capital expenditure, recurring annual costs, and a one-time end-of-life cost, all discounted to their present values. The present value life cycle costs were found to be €1,683 per square meter for green buildings and €1,420 per square meter for traditional buildings. Despite the higher initial costs associated with green buildings, the long-term financial analysis reveals substantial benefits.

It is concluded from this whole research that, green buildings require a higher initial investment due to the use of sustainable materials and advanced technologies. This investment is reflected in the higher present value life cycle cost. However, this upfront expenditure is necessary to achieve long-term sustainability and efficiency. Green buildings benefit from lower annual operating costs due to energy-efficient systems, reduced water usage, and other sustainable practices. These savings accumulate over time, offsetting the initial higher costs and leading to a lower total cost of ownership. In addition to financial savings, green buildings offer significant environmental advantages, including reduced carbon emissions and resource consumption. They also contribute to better indoor air quality and enhanced occupant health and well-being, aligning with broader sustainability goals. Last but not the least the NPW analysis indicates that, over a 40-year period, green buildings can provide significant long-term financial benefits compared to traditional buildings. The higher present value life cycle cost is mitigated by the accumulated savings in operational and maintenance expenses, making green buildings a sound investment.

These findings suggest that investing in green buildings can lead to substantial long-term financial gains, despite higher initial costs. Developers and investors should consider the total cost of ownership and the potential for long-term savings when making investment decisions. Also the results support the promotion of green building practices through incentives and regulations. By encouraging sustainable construction, policymakers can help reduce environmental impact and improve public health. Green buildings offer improved indoor environmental quality and enhanced quality of life.

Occupants can benefit from healthier living and working environments, leading to increased satisfaction and productivity.

In conclusion, the LCCA demonstrates that green buildings, despite their higher initial costs, offer substantial long-term financial, environmental, and social benefits compared to traditional buildings. As the demand for sustainable solutions grows, the advantages of green buildings are likely to become even more pronounced, making them a preferable choice for developers, investors, and policymakers committed to sustainability and long-term value creation. Investing in green buildings is not only a financially sound decision but also a crucial step towards a more sustainable and healthier future.

5.1 Recommendation for future works

To build on the findings of this study, future research should consider expanding the scope to include a larger and more diverse sample of residential buildings across different regions of Albania. This would provide a more comprehensive understanding of the economic and environmental benefits of green buildings in various contexts.

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