Impediments in Energy Efficient Building Retrofitting: With Special Reference to Public University Buildings in Sri Lanka

R G A M Premakumara[a] and H T Wickremasinghe[b*]

[a&b] *Department of Estate Management and Valuation, University of Sri Jayewardenepura*

Abstract

In a world where sustainability and energy conservation have taken center stage, the building sector, which happens to be the largest consumer of energy, finds itself at a critical crossroads. As sustainability and energy reduction become increasingly important, building retrofitting is recognized as a viable and sustainable solution. Retrofitting involves integrating new features and technology into existing buildings to enhance their efficiency. Despite the acknowledged need for building retrofitting, there is relatively low concern within the public sector, including university buildings. Various barriers hinder the adoption, implementation, and operation of energy-efficient retrofits in public university buildings in Sri Lanka. This study aimed to investigate these impediments. Qualitative methods were employed, and five professionals, including three architects and two institutional hierarchical heads in Finance and Legal Units, were interviewed. Data analysis was conducted using content analysis. The findings highlighted financial, procurement, energy assessment, technical, and legal aspects as barriers to energy-efficient retrofitting in public university buildings. Among these, technical barriers emerged as the predominant impeding category. Therefore, the authors recommend future studies to focus on in-depth examinations of technical barriers and their impacts on building retrofitting. Authors suggested several policy level implications as well.

Keywords: Energy consumption; Energy efficiency; Building retrofitting; Impediments; Public building

Introduction

Energy is essential for the development and survival of all human beings and energy generation is one of the most pressing and important needs of every country in the process of economic growth and development (Feng et al., 2010). Building is the largest energy consumption sector and accounts for approximately 40% of global energy consumption (Mumovic & Santamouris, 2009). Lighting, heating, ventilation and air conditioning (HVAC) and office instrument consume a significant share of energy in buildings. With the increasing focus on sustainability and reducing energy consumption, building retrofitting has identified as a sustainable solution. Retrofitting a building involves incorporating new features and technology into it in order to increase its efficiency and effectiveness and reduce the resources used for building construction and the costs of the building's operations and maintenance expenses (Feng et al., 2010; Ali & Hashlamun, 2019; Athukorala & Wilson, 2010).

In present situation in Sri Lanka, energy is not used in a sustainable manner in every sector. Sri Lankan's electricity demand is increasing rapidly (Fernando & Jayasena, 2018). Therefore, the public sector also has a responsibility to contribute in this as it includes a large range of different type of buildings from local authority administration buildings, schools, government university, hospital to many other public buildings. The existing public buildings need to be retrofitted to be energy efficient (Bandara & Attalage, 2008).

* Corresponding author: hashini@sjp.ac.lk

A systematic energy audit done using another Sri Lankan government university during December 2014 and February 2015 revealed that university consumes 44% for air conditioning and 21% for lighting which account for 65% in total. This indicates poor electricity management procedures in public buildings (Centre for sustainability Solution, 2015).

Although energy efficiency and sustainability are now fundamental issues for any construction, the concern of public sector in this regard is relatively low. Moreover, despite the fact that the necessity of building retrofitting is well acknowledged, it is clear that there are number of barriers faced in adopting, implementing and operating new energy efficient building retrofits in the public sector buildings including university buildings. Thus, this study aimed at exploring the impediments in the energy efficient building retrofitting with special reference to public University buildings in Sri Lanka.

The Objective of the Study

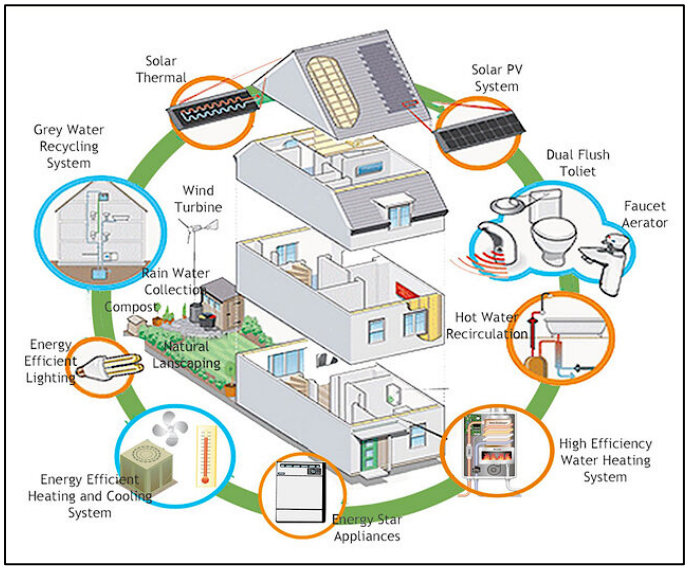
The objective of the study is to explore the impediments in the energy efficient building retrofitting with special reference to public university buildings in Sri Lanka.

Literature Review

Building retrofitting

Creating energy efficiency in building is a key component of energy preservation. Retrofitting a building involves incorporating new features and technology into it in order to increase its efficiency and effectiveness. As shown in Figure 01 below, there are various elements in energy-efficient building retrofitting.

Figure 01: Various Elements of Energy-Efficient Buildings



Source: Maurya et al. (2021)

Since the lifespan of the building's structure and fabric is significantly longer than that of the installed components, retrofitting is frequently connected with buildings (Khodeir, Aly & Tarek, 2016). Research has shown that building retrofit can reduce energy use in buildings by up to 80%, and that 90% of the world's building stock has to be retrofit in order to convert existing

structures into nearly zero-energy structure (Khadra & Myhren, 2020). Building energy retrofit has the potential to be quite important for save energy (Krarti & Alubyan, 2020). Energy retrofitting change the functionally and physically within the building, to reduce amount of energy needed for its energy consumption equipment or the behavior of its occupants and converting the building to a low energy convenience. (Jafari et al., 2017). The three efficient ways to lower energy use in existing office buildings are, make the building envelop more airtight and insulated and efficient sun-shading system, make the most of natural ventilation and day illumination and put in energy-saving lighting and intelligent control system (Wang et al, 2013).

Barriers in energy efficient retrofitting of public buildings

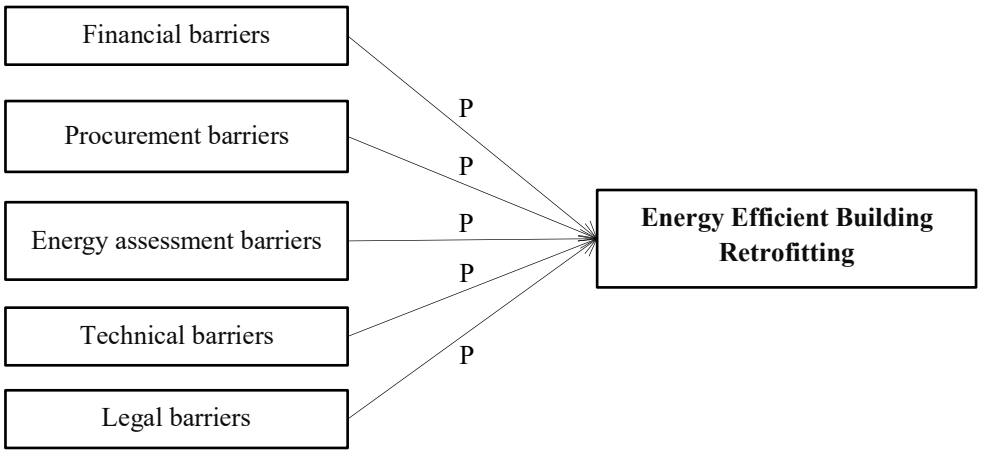
This study is based on five selected barriers regarding the energy efficient retrofitting of public university buildings. The **financial barriers** include lack of motivation to invest, split incentives (Ernst & Young, 2015), inadequate financing, debt restrictions, lack of specified financing mechanism (Beillan, 2011). When it comes to **procurement barriers**, those include logistical and geographical difficulties, agency-wide knowledge and skill gaps, inadequate competent contractors and complicated government procurement process (Bertone et al, 2017; Alam et al., 2018). The **energy assessment barriers** include a lack of financing, metering, qualified experts, institutional processes and lack of long-term plan, lack of metering, lack of resources for evaluate opportunities, inadequate awareness of energy assessment and lack of funds for install new metering device (Bertone et al., 2017). In addition, **technical barriers** consist of lack of access to efficient technologies, lack of availability and dependability of efficient technologies, inexperience technology, lack of consistent and standardized solutions for integrated solution complying with new standards, shortage of skilled works, safety risk associated with extensive renovation process and inadequate technical expertise (Beillan, 2011; Ferrante et al., 2018). The **legal barriers** include ineffective building energy efficient codes, rules and standers, difficult certification process, ineffective codes/regulations distribution, lack of energy efficiency understanding on the part of legislator and regulation (Beillan, 2011; Cristino et al., 2021).

Methods

Study Design

The factors identified in the reviewing literature are used to develop the conceptual model shown in Figure 02. The dependent variable is energy efficient building retrofitting and the independent variables are the five barriers.

Figure 02: Conceptual Framework



Source: Authors (2022)

Propositions

Table 01: Proposition of the Study

Proposition	Statement
P_1	Financial barriers negatively affect energy efficient building retrofitting
P_2	Procurement barriers negatively affect energy efficient building retrofitting
P_3	Energy assessment barriers negatively affect energy efficient building retrofitting
P_4	Technical barriers negatively affect energy efficient building retrofitting
P_5	Legal barriers negatively affect energy efficient building retrofitting

Source: Author (2022)

Case study area

In general knowledge, building density is high in Colombo area than other area. A general rule of thumb states that structures need to be retrofitted (on a medium level) every 50-60 years and significantly every 120 years of existing building (Gindi et al., 2017). Hence, this study focused on the public university of University of Sri Jayewardenepura established in 1873 as it is one of more than 50 years old public universities located in Colombo, Sri Lanka. Then, more than 50 years old buildings such as Bandaranayake Hall and Sri Sumangala Mansion which are over 60 years old were selected for this study. Figures 03 and 04 show the images of the buildings.

Figure 03: Sri Sumangala Mansion

Source: University of Sri Jayewardenepura Website (2022)

Figure 04: Bandaranayaka Hall

Source: University of Sri Jayewardenepura Website (2022)

Population, Sample and Survey Instrument

The data was collected through a semi-structured interview targeting expert professionals such as three architects, and two institutional heads selected using judgmental sampling manner. For the data collection, both primary and secondary sources were used. Secondary data collection was done through reviewing journal articles, reports, web articles, blogs, etc. Primary data were collected via semi-structured interviews using a semi-structured interview guide. The first section of the interview conducted information about respondents' background while the second section of interviews focused on evaluation of respondents regarding the barriers in retrofitting public university buildings. Content analysis was used for the data analysis.

Profiles of respondents

Table 02 shows the profiles of the respondents of interviews

Table 02: Profiles of respondents

Respondent description	Respondent 01	Respondent 02	Respondent 03	Respondent 04	Respondent 05
Name	Respondent 1 (R1)	Respondent 2 (R2)	Respondent 3 (R3)	Respondent 4 (R4)	Respondent 5 (R5)
Gender	Female	Male	Female	Male	Female
Position	Deputy Financial bursar in University of Sri Jayewardenepura	Architect, Senior Lecturer in University of Sri Jayewardenepura, Architect	Architect, Senior Lecturer in University of Sri Jayewardenepura, Architect	Architect, Self-employment (Architect, building conservator, project Management)	Legal Advisor, Senior Assistant registrar in University of Sri Jayewardenepura
Years of service	31	10	25	28	12
Educational Qualifications	MSc in Applied Science, PGT in Cooperate finance and Strategic finance, B. Com	B.Arch. (Architecture), PhD (Civil Engineering), MSA Civil Engineering, 3D Printing Certificate course,	B.Sc. (Build Environment) Hons SL, M.Sc.(Architecture) SL, M.Sc. (Urban Design) Toronto, PhD	B.Sc. (Build Environment), M.Sc. (Architecture)	Master in labour relation and human resource management, labour and industrial relatio Bachelor of laws LLB
Professional qualifications	MAAT	Chartered Architect AIA (SL), Sri Lanka Institute of Architect,	FIA SL	Chartered Architect, Attorney at law	Attorney at Law
Working experiences	Financial Function: Budgeting, Financial instrument handling, Administration, Procurement and HRM	Building Design, Construction, Project supervisor, Green Building, Specialty building materials	Architecture; Practice & Teaching	Architecture, Project Management, conservation	Analytical experience, legal advice
Scope or key responsibilities	Financial responsibilities	Building design; project supervision, building material	Building design; conceptualization, design, detail, construction administration.	As consultant architect, building conservator handle many responsibilities	Engagement in legal practices, Litigation and case management.

Source: Interviewed Data (2022)

Results and Discussion

This study is to explore the impediments in the energy efficient building retrofitting of public university buildings in Sri Lanka. Based on the public building retrofitting reviewed in literature review, five variables such as financial, Procurement, Energy assessment, Technical and Legal and regarded as very important factors in barriers of building retrofitting when increase energy efficient within public university building.

Advantages of energy efficient of building retrofitting

The advantages of energy efficient building retrofits demonstrate the success of energy efficient building retrofits. Further, although significant advantages can be experienced in retrofitting buildings in an energy efficient manner, there are also faced to disadvantages to retrofitting buildings. Table 3 summarises both advantages and disadvantages of energy efficient buildings retrofitting.

Table 03: Advantages and Disadvantages of Energy Efficient Building Retrofitting

	Validated Source	Respondent(s) who Validated
Advantage		
Maximizing energy savings	Literature	R3
Improve energy efficiency, increased energy efficiency, minimized the use of electricity energy and material reduction, reducing the impact on the environment, cost effective, grown production capacity and optimizing the performance of building components	Literature	R3, R4
Retrofit does not affect the architecture of old building, people who appreciate historical buildings	Professionals	R2, R4
Disadvantage		
When retrofitting buildings of colleges and universities have to take different types and complicated actions	Literature	R2
Complex and difficult task	Professionals	R2
Damage the architecture of historical building / damage the design and antiquity of older buildings	Professionals	R3, R4

Source: Interviewed Data (2022)

Barriers of Energy Efficient Retrofitting of Public University Buildings

Table 04: presents the factors that affect to energy efficient retrofitting of public university buildings under selected barrier categories.

Barriers	Literature	R1	R2
Financial			
Estimated amount was not received.	√	√	
It is challenging for the government institutions to obtain funds from the treasury department to undertake energy saving projects.	√	√	
Not sending properly prepared financial budget of building retrofit to the annual budget.	√	√	
Procurement			
Material price fluctuation and price excavations affect to procurement decisions.		√	
No proper procurement guideline or precise instructions outlining the process.	√	√	
No transparency in procurement procedure and the government procurement process is too complicated.	√	√	
Failure to obtain high quality raw materials.		√	
There are no government officers genuinely and continuously supporting energy saving projects.		√	
Energy Assessment			
No proper or standard energy efficiency metering devices.	√		√
Low-cost energy efficiency metering devices have been installed.	√		√
Energy consumption is not measured in public buildings due to lack of awareness.	√		√
Not using new technology.			
Lack of positive attitude of responsible individuals on energy assessment.			
Assessing the energy efficiency is a complex task with available resources.			
No policy or guiding notes on monitoring and auditing of energy assessment.			
Technical			

The structural arrangement of the building can be a barrier.	√	
Load bearing capacity of old building is not known.	√	
No building plan or no approved building plans.	√	
Complex building design or design defects.	√	
High preference and biased people's attitudes towards using air-conditioning, artificial lighting or ventilation mechanisms in buildings.	√	
Lack of technical expertise in building energy efficient retrofit and monitoring.	√	
Lack of access to efficient and new technologies for building energy efficient retrofit.	√	
Legal		
Not properly prepared building energy efficient codes, rules and standards.	√	
Ineffective building energy efficient codes, rules and standers and legislator and regulation.	√	
Complicated certification process and have to follow that process to get approval for retrofit plans of public buildings.	√	
Obtaining various approvals for building retrofitting plans.		
Building planning regulation differ according to the local authority.		

Source: Interviewed Data (2022)

As shown in Table 04, technical barrier category is the most predominant barrier that negatively affect energy efficient retrofitting of public university buildings. Accordingly, the data collected via expert professionals' interviews validated the previous study findings done by Beillan (2011) and Ferrante et al. (2018) which were similar to current study's findings. The result implies that building structure or architectural design is highly important factor under technical barrier that affects retrofitting public university building in Sri Lanka for energy efficiency. In addition, lack of technical expertise and lack of access to new technologies were also highlighted both in literature and by the interviewed professional architects. For instance, R4 highlighted that, "*Professionals with the right education should be deployed to handle the design of building service systems, such as trained services engineers who are up-to-date with the latest technology and resources to these tasks*". However, all the other barrier categories also act as impediments in energy efficient retrofitting of public university buildings, as they are essential parts of the whole process, agreeing to findings of previous scholars (Beillan, 2011; Alam et al., 2018; Cristino et al., 2021). Thus, those areas also should be paid considerable and immediate attention.

Conclusion and Implications

Building is the largest energy consumption sector. With the increasing focus on sustainability and reducing energy consumption, building retrofitting has identified as a sustainable solution. Retrofitting a building involves incorporating new features and technology into it in order to increase its efficiency and effectiveness. However, despite the fact that the necessity of building retrofitting is well acknowledged, the concern of public sector in this regard is relatively low and it is clear that there are number of barriers faced in adopting, implementing and operating new energy efficient building retrofits in the public sector buildings including university buildings. Thus, this study aimed at exploring the impediments in the energy efficient building retrofitting with special reference to public University buildings in Sri Lanka. The study adopted qualitative method and interviewed five professionals consisted of three architects and two institutional hierarchical heads in Finance and Legal Units. Content analysis was used for the data analysis. The study findings revealed that the financial, procurement, energy assessment, technical and legal aspects act as barriers for energy efficient retrofitting of public university building. The predominant barrier category was identified as technical barriers. Thus, the current authors suggest future studies to focus on in-depth studies to explore technical barriers and its related impacts on building retrofitting. As policy level implications, the authors suggest that, at the building approval stage it is recommended to expand the internal group of experts with relevant technical knowledge with genuine interest on energy saving. Further, a comprehensive national

framework can be established that outlines the goals, standards, and guidelines for building retrofitting, since the country has around 16 government universities where over half of it has over 50 years' history as well as at least one 50 year old building in each. Moreover, technical assistant can be obtained with proper proposals, via external fundings both local and foreign as funds are allocated for sustainable measures by various agencies and authorities.

Acknowledgements

The authors acknowledge the Centre for Real Estate Studies (CRES), Department of Estate Management and Valuation, University of Sri Jayewardenepura, Sri Lanka.

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