Barriers to retrofitting buildings for energy efficiency in South Africa

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Abstract. Literature has established the enormity of energy consumed by buildings. The processes involved in generating and distributing this energy, and most especially its usage is identified as causing a significant adverse environmental impact. As a strategy for enhancing the effectiveness and efficiency of existing buildings through the introduction of new technologies, retrofitting has become another avenue for achieving sustainability in the construction industry. This paper, therefore, seeks to identify the major barriers to retrofitting buildings for energy efficiency in South Africa. A structured questionnaire survey was used as the instrument for data collection. Data for the study were gathered from construction professionals (architects, civil engineers, quantity surveyors, project managers, construction managers, and energy engineers) with experience in building retrofit projects. A quantitative approach to data analysis was adopted using percentage, standard deviation, and mean item score. From the data analysed, the results revealed low income, high investment costs, occupant’s resistance, high upfront cost, and low consumer appeal as the top five barriers. The findings from this study will help improve and encourage retrofitting buildings for energy efficiency which is believed to have the potential of drastically reducing the long-term cost of energy consumption, greenhouse gas emissions and carbon footprint.

Keywords: Construction industry, Energy consumption, Environmental impact, Retrofitting, Sustainability

1. Introduction

Energy is an essential resource as virtually all human operations are dependent on it. The importance of energy to the growth and development of any nation (developed and developing) cannot be disputed. As compared to other sectors of the economy, buildings are known to have a high percentage of energy consumption, although the rate of each country and region differs [1, 2]. For example, the industrial sector is the largest consumer of energy at almost 62 percent while the domestic/household consumption account for 20 percent of the total energy consumption in South Africa [3]. It is therefore difficult for the government to meet all the energy needs of the increasing population, leading to load shedding in some parts of the country and total blackout in some other parts. In Nigeria, the slow pace at which the economy grows is attributed to the issue of energy as all commercial and industrial operations is solely dependent on it. The inefficiency of the energy sector has also crippled the growth and development of Small and Medium Enterprises (SMEs) which are known to be a significant driver of the economy in
developing countries. As affirmed by [4], lack of access to energy significantly lessen the chances of eradicating poverty and constitute a crucial barrier to the growth and development of the economy. In summary, there are numerous negative issues attributed to lack of access and inadequacy of energy in any country. It is, therefore, imperative to make efforts in enhancing efficient energy use and reduction in energy consumption.

The term energy efficiency originates as a response to the various challenges encountered through energy use. Energy efficiency can be described as the ability to do more task with less energy [5]. Many stakeholders in the energy industry believed that energy efficiency offers a positive avenue through conservation policies thereby saving cost [6] and reducing negative environmental impacts associated with energy use. Reduction in the per unit price of energy is considered as one of the prime gains of efficient consumption of energy [7]. As supported by [8], energy efficiency reduces the cost of energy, making its use more affordable and a paramount avenue for reducing carbon footprint. Energy efficiency is considered as the panacea to curbing and mitigating greenhouse gas emissions and a vital factor in achieving energy policy goals [9]. It is against the backdrop of the essentials of energy efficiency that this study aims to assess the barriers to building retrofitting for energy efficiency in South Africa.

This paper is part of a recently completed research study that assesses energy efficiency in retrofitted buildings in South Africa. It reveals the results of the questionnaire survey of the construction professional’s view on the factors that constitute the barriers to retrofitting buildings for energy efficiency. By identifying the barriers, the study aims to encourage stakeholders in the construction industry on the need to incorporate energy efficiency measures in the construction process. While the data is derived from Gauteng province, South Africa, the findings from the study have the potential of global application, especially in growing and developing countries.

2. Building retrofitting for energy efficiency

Retrofitting is popularly associated with buildings since the lifespan of building structure and fabric is considerably longer than the installed components [10]. Research has proven that the retrofitting of existing buildings is one of the significant ways of drastically reducing greenhouse gases emissions and energy consumption on a global scale. From the various definitions by different literature, it can be inferred that building retrofitting is the addition and utilisation of new technologies and features to buildings to enhance their effectiveness and efficiency. According to [11], a building will require a significant retrofitting at least once in their lifetime to prevent deterioration to the point at which they become uninhabitable. On the other hand, a rule of thumb is that buildings require refurbishment (medium level) every 50-60 years and a major one every 120 years [12]. However, economic analysis, building performance assessment, energy auditing, quantification of energy benefits, measurement and verification (M&V) of energy savings, and risk assessment are all identified by [13] as significant to the success of a building retrofitting project.

A large amount of energy is consumed by most buildings (specifically educational) in hot, arid climates [14] The processes leading to the production, generation and distribution of energy is identified as having a negative environmental impact on the ecosystem and human life. Also, most of the existing buildings are constructed at a time when effectual energy efficiency components are lacking within the relevant building codes [15]. Retrofitting has, therefore, become one of the ways of addressing the issue of energy consumption in buildings. Although energy is not the main reason for building retrofitting, full consideration should, however, be given to the renewal and efficiency of energy systems in any retrofitting project [11]. As highlighted by [16], other objectives of building retrofitting include redefining the floor layout, counteracting a poor state of repair, increasing indoor comfort conditions and reducing energy use.

3. Positives and negatives of building retrofitting for energy efficiency

Construction professionals and other relevant stakeholders are faced with numerous challenges when addressing building retrofitting owing to its importance. It is noteworthy that the decisions taken at the early stages of the design and construction process have a significant impact in determining the success or failure of such project [17]. Since decision making responsibility rests so much on the stakeholders, it can be deduced that they determine the success or failure of a building retrofitting project. Difficulty
in procuring required materials and components, and high initial cost involved are identified by [18] as challenges involved in a building retrofitting project. Another difficulty is the challenges of regulating and improving energy efficiency in existing buildings as compared to new constructions [19]. With new buildings, it is much easier to employ energy efficiency components and technologies rather than incorporating such through retrofitting. Non-existent or incomplete building specific information is listed as another significant challenge by [20]. As listed by [21], difficulty in enforcement and monitoring of compliance with energy codes during retrofits, little or no incentives for building owners to invest in higher energy efficiency than required norms, and absence of regulatory power to mandate improvements in building performance are challenges/barriers to a building retrofitting project for energy efficiency. Others are reluctance or failure of building managers/owners to voluntarily submit energy consumption data, low attractiveness of government-mediated financing with private institutions, uncertainty over continued participation of building occupants over the consecutive years, low attractiveness of short-term financial incentives for retrofitting, and absence of innovative measures to overcome industry resistance.

Regardless of the challenges of building retrofitting for energy efficiency, the benefits are significant and cannot be over-emphasised. As listed by [22], improved material resources efficiency, improved energy efficiency, minimised energy and material losses, reduced environmental impacts, cost savings, increased production rate, and optimisation of building components performance are benefits of retrofitting. From Table 1, [21] classified the benefits of building retrofitting for energy efficiency into three groups namely; social benefits, market benefits, and environmental benefits. The benefits of building retrofitting for energy efficiency when compared to the challenges are enormous and imperative in meeting the sustainability objective of the construction industry.

| Social | Market | Environmental |
|--------|--------|---------------|
| Provides baseline and annual energy consumption which allows building managers/owners to monitor improvement measures | Job creation through increased demand for energy engineers and auditors | Rapid reduction in energy usage |
| Provides transparent building energy efficiency for prospective tenants/buyers and the public | Saves energy expenditures following improved building management or retrofitting | Reduces greenhouse gas emissions |
| Provides information to building owners on potential retrofitting actions, costs and payback periods | Increases the growth of green building and energy efficiency certifications such as Energy Star | Reduces energy consumption |
| Enhance capacity to improve environmental performance | Creation of carbon market | Assured conformity of newly installed building systems to specific energy efficiency norms |
| Secures smaller building participation | Stimulates retrofitting activities | Rapid reduction in water usage |
| Fosters tenant and owner relations and sustainable office practices | Saves operational expenditures arising from high building system components | Encourages the use of renewable energy |
| Users/occupants involvement through a holistic approach to building sustainability | Increases the uptake of energy efficient retrofitting technologies and building system components | Assured operation of building systems at most energy efficient level |
Since the building sector alone contributes 40 percent of total energy consumption and one-third of greenhouse gases globally, the sector represents the best avenue with a vast potential for reducing harmful emissions and energy usage [23]. It is based on the afore-mentioned that this paper assesses the barriers to retrofitting buildings for efficient use of energy in South Africa.

4. Research Methodology
This research paper employed the combination of secondary data (literature review) and primary data (questionnaire survey) to present the barriers to retrofitting buildings for energy efficiency in the Gauteng province of South Africa. A structured questionnaire survey was administered to construction professionals such as architects, civil engineers, quantity surveyors, project managers, construction managers, and energy engineers who are involved in building retrofitting projects. The questionnaire containing close-ended questions was divided into two sections to harness information from the respondents. The first part of the questionnaire sought information about the background of the respondents such as their years of experience, professional affiliation, educational background, organisation worked for, and history of involvement in retrofitting projects. The second part of the questionnaire sought the respondent’s evaluation of the barriers to the retrofitting of buildings for energy efficiency. The respondents were asked to indicate their level of agreement on the identified variables on a five-point Likert scale (strongly disagree-1, disagree-2, neutral-3, agree-4, strongly agree-5). To analyze the data obtained, the aid of Statistical Package for Social Sciences (SPSS) Version 16 software was used to analyze the data obtained. Descriptive statistics with the aid of standard deviation and mean scores was used to present the result of the analyzed data.

5. Findings and Discussion
5.1. Background information of respondents
The results of the analyses of the data gathered on the respondents’ background are as follows. For the professional affiliation of the respondents, the results revealed that Quantity surveyors represents 22 percent, Architects represent 20 percent, Civil engineers represents 18 percent, Project managers and Construction managers represents 16 percent respectively while energy engineers represent 8 percent. Also, the results showed that 36 percent had experience that ranged between 1-5 years, 34 percent had experience that ranged between 6-10 years, 14 percent had experience that ranged between 11-15 years, 14 percent had experience that ranged between 16-20 years, 14 percent had experience that ranged between 21-25 years while 2 percent had experience from 26 years and above. Most of the respondents work within the private organizations representing 94 percent while the remaining 6 percent work within the public organization. As presented in Figure 1, 18 percent of the respondents have not been involved in any building retrofitting project, 36 percent have been involved in 1-2 building retrofitting projects, 28 percent of the respondents have been involved in 3-4 projects, 16 percent of the respondents have been involved in 5-6 projects, none of the respondents have been involved in 7-8 projects while 2 percent of the respondents have been involved in more than 8 projects.

![Figure 1. Respondents history of involvement in building retrofitting projects.](image-url)
5.2. **Barriers to retrofitting buildings for energy efficiency**

The result in Table 2 presents the agreement level of respondents on the barriers to building retrofitting for energy efficiency in South Africa. The results revealed that all the 25 variables assessed have mean values above 2.5 [24] with the minimum been a high value of 3.02. This result implies that all the variables are highly significant barriers that influences retrofitting buildings for energy efficiency. However, the respondents considered that ‘low income’, ‘high investment cost’, ‘occupants resistance’, ‘high upfront costs’, and ‘low consumer appeal’ as the top five barriers to retrofitting buildings for energy efficiency. Lack of personal incentive, lack of energy professionals, lack of monitoring, status quo, and lack of energy efficient materials and components as the least five barriers to building retrofitting for energy efficiency. The results are in tandem with the studies of [18], and [21] amongst others where the issues of high financial investment, occupants and owner’s resistance due to low awareness on the benefits, and low income of building owners/occupants are predominant.

| Barriers                                                                 | Mean  | Standard Deviation | Rank |
|-------------------------------------------------------------------------|-------|--------------------|------|
| Low income                                                              | 4.16  | 0.842              | 1    |
| High investment cost                                                    | 4.14  | 0.756              | 2    |
| Occupants resistance                                                    | 3.98  | 0.845              | 3    |
| Low consumer appeal                                                     | 3.96  | 0.807              | 4    |
| High upfront costs                                                      | 3.96  | 0.605              | 5    |
| Lack of municipal support                                               | 3.82  | 0.873              | 6    |
| Misconception on retrofitting technologies                              | 3.80  | 0.904              | 7    |
| Occupant’s disruption                                                   | 3.80  | 0.857              | 8    |
| Building orientation                                                    | 3.72  | 1.089              | 9    |
| Immature market                                                         | 3.68  | 0.794              | 10   |
| Lack of education                                                       | 3.62  | 0.878              | 11   |
| Lack of knowledge                                                       | 3.60  | 0.857              | 12   |
| Capital risk                                                            | 3.58  | 0.810              | 13   |
| Poor quality installation                                               | 3.58  | 0.883              | 14   |
| Lack of technical expertise                                             | 3.50  | 0.909              | 15   |
| Lack of cost-effective components                                       | 3.34  | 0.872              | 16   |
| Building owner’s lifestyle choices                                      | 3.26  | 1.026              | 17   |
| Lack of capacity                                                        | 3.26  | 0.922              | 18   |
| Lack of information                                                     | 3.22  | 1.016              | 19   |
| Lack of incentive for investors                                         | 3.22  | 0.887              | 20   |
| Lack of personal incentive                                              | 3.18  | 0.962              | 21   |
| Lack of energy professionals                                            | 3.16  | 0.934              | 22   |
| Lack of monitoring                                                      | 3.04  | 0.755              | 23   |
| Status quo                                                              | 3.02  | 1.020              | 24   |
| Lack of energy efficient materials and components                        | 3.02  | 0.869              | 25   |
The success of a building retrofitting project is dependent on availability of finances and the willingness and compliance on the part of building owners/occupants. It is believed that achieving energy efficiency comes at a huge cost when factors such as spending less on energy consumption and personal incentives which are regarded as long-term benefits are not considered. Lack of awareness and information on the concept of building retrofitting for energy efficiency has also created uncertainties around the return of investment. Low consumer interest and appeal also occur as a result of the high upfront and investment costs when not considering the huge amount of cost to be saved over the building’s lifecycle.

6. Conclusion and Recommendations
This research paper aims to identify the barriers impeding the retrofitting of buildings for energy efficiency in South Africa. Based on the findings revealed from the data gathered from the respondents (architects, civil engineers, quantity surveyors, project managers, construction managers, and energy engineers) within the Gauteng province of South Africa, the major barriers to retrofitting for energy efficiency were identified. From the study, it is concluded that the major impediments include low income, high investment costs, occupant’s resistance, high upfront cost, low consumer appeal, and lack of municipal support. If the aim of energy efficiency will be achieved in any building retrofitting project, then the stakeholders need to be knowledgeable and aware of the benefits accrued to such exercise. It has been established that energy efficiency in buildings is a major way of reducing the concentration level of carbon footprint and greenhouse gas emissions. Hence, retrofitting buildings for energy efficiency can be inferred as another avenue towards achieving the sustainability objective of the construction industry. Support from government through incentives, policies and legislations is also believed will in turn contribute to the success of retrofitting buildings for energy efficiency. With proper awareness and knowledge on the overall and long-term cost-benefit of retrofitting buildings for energy efficiency, building owners fear and occupant’s resistance will be eliminated leading to the success of the retrofitting project.

While the study identifies the barriers to building retrofitting for energy efficiency in the Gauteng province of South Africa, extreme caution must be taken in generalizing the results. This is due to the identified limitations of the geographical location and the number of respondents sampled. It is however recommended that further study can be carried out to cover more provinces and respondents in order to get a robust view and results.

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