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Factors Influencing the Use of Green Building Practices in the South African Residential Apartment Construction

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***Abstract*—**Although its use has been criticised over the years as being unencouraging, the green building concept is quickly overtaking other concepts, particularly in the construction of commercial properties. The goal of the study is to identify the variables influencing the use of green building practices when developing residential structures. A qualitative methodology, using interviews with semi-structured open-ended questions to 35 property practitioners operating residential apartments in Bloemfontein, South Africa, was used to collect primary data which were analysed using thematic content analysis. The findings show that while respondents have a good understanding of green building principles, they are not being used in the construction of residential buildings in South Africa due to issues with green building approval procedures, the potential for tenant rent increases, the cost of materials, technical issues, contractual issues, and a lack of awareness, among others. This paper recommends among others an urgent need to implement measures by stakeholders towards enhancing the adoption of green building concepts in the construction of residential buildings as well as incentivising its construction through lowered property rates.

***Keywords*—**Green building, residential apartments, construction, South Africa.

I. Introduction

As building users' needs change over time, it is essential that buildings adapt to meet those changes and have the flexibility to accommodate a variety of uses while allowing the users to enjoy the spaces at various times [1]. Sodiq et al. [2] indicated that because buildings serve as human habitations, it must be adaptable such that it keeps up with the changes in people's values, behaviours, and morals. Residential apartments are indicated to make up a greater portion of the real estate industry and there are discussions as to why the sector has not taken the initiative to implement green building principles [3]. One of the most significant opportunities to reduce human carbon footprint on the environment is to increase energy efficiency in building construction and operation [4]. Oluwunmi et al. [5] argue that residential apartments can be sustained by implementing green building principles but according to [6], the level of adoption in practice, is deficient, and most likely, the hindrance to its adoption is ignorance.

Despite an increase in the number of homes certified as energy-efficient under national standards like Energy Star and LEED and local standards, there has not been standardised publicly available data on the energy efficiency of homes [7]. Green-labelled houses are indicated to operate more affordably than their conventional counterpart, and their ratings exceed the minimum standards set by building codes, however, the owners of these properties appreciate the green spaces and superior indoor air quality over energy savings [8].

While the majority of the people have doubts about the long-term viability of investments in energy-efficient building construction, authors such as [9] posited that energy-efficient buildings can generate statistically significant positive green price premia in both their rental and sale markets.

Franco et al. [10] also noted that there is not much confidence in the green building industry on energy efficiency investments, as property owners only gain a portion of the benefits from their investments and get a lower rate of return. Kapoor et al. [11] documented that financial reports of Singaporean property owners do not prove that energy efficiency investment improves residential developers' financial performance. Deng and Wu [9] thus argued that these reports may demotivate investors from being involved in future energy efficiency ventures. Zhang et al. [12] have also indicated that in some parts of the world, green features such as green roof technology and solar systems lack awareness and expertise. According to [13], the reason for this is the high cost of these appliances and the lack of motivation from customers' demand because of the marketing and low production of green materials sale.

While South Africa has made some improvements in the green building space, it has not yet reached a maturity level comparable with countries such as the United States, the United Kingdom, or Australia [14]. This suggests a needs to do more in it designs of the built environment and towards this, the Department of Trade and Industry (DTI) amended the sections of the National Building Regulations (SANS 10400) that relate to environmental sustainability and energy usage in buildings [15]. The interpretation of the amended regulations is not standardised and remains a challenge. O'Rourke [16] in his study emphasised costs as a key driver of change while the lack

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of market knowledge is highlighted as a central theme that inhibits the green building effort in South Africa. With this background, this study seeks to identify the factors influencing the use of green building practises in the South African residential apartment construction and make recommendations towards encouraging the practise. The next section presents literature around the subject.

II. Principles of Green Buildings

Green buildings (GB) have also been referred to as energy-efficient structures, environmentally friendly structures, eco-structures, and high-performance structures [17]. GB principles include using non-toxic, recycled building materials, environmentally responsible energy sources, and a building's overall life cycle with minimal impact on the landscape and environmental condition [18]. It includes methods for designing, building, and operating that lessen or completely eliminate the negative effects of development and energy performance on the people and the environment [19].

A. Features of GB

a. Energy Efficiency

Energy performance can be affected by natural lighting used as a design strategy and the shape and orientation of the building [20]. GB tend to generate energy, thus minimising the usage of energy in the building and reducing the impact it has on the environment, and also contributing to reducing the operational costs [19]. GB can have energy-saving from between 25% to 50% compared to conventional buildings in terms of reducing operational costs [21]. It is necessary to separate the new building from the existing ones to promote energy-efficient and sustainable buildings to comply with standard regulations. New buildings can be constructed to have energy and environmental quality, but renovating existing buildings is the most challenging, which is why they are characterised by scarce performance [22].

Gamagara Municipality [23] emphasises that legislation for energy efficiency in South Africa regulates energy use in buildings for design and operations. This standard is mandatory for all new buildings and extensions to existing ones [22]. Building energy efficiency is impeded if there is inefficient enforcement of legislation [24] and it is important that that the legislation is timely revised and incentivised for innovation [22]. The reduction of building energy consumption has gained interest because it has been addressed as an issue associated with greenhouse gases and residential buildings use most energy on space conditioning [25]. In 2005, US residential buildings surveyed the top four energy end-uses, which included space heating at 30.7%, space cooling at 12.3%, water heating at 12.2%, and lighting at 11% of the energy consumed in buildings and the list of essential energy end-uses includes refrigeration, electronics, wet cleaning, cooking, and computers [25]. The efficiency of the energy end users is the focus of GB [26].

b. Water Efficiency

Water efficiency is not restricting the use of water but focusing on reducing water usage and waste [19]. Kajimo-Shakantu et al. [27] stated that conventional buildings waste water resources and it accounts for one-sixth of the world's freshwater withdrawals. Since people view water as a precious resource, their behaviour can be linked to how effectively they prevent water waste and implement effective systems to deal with this problem [28]. This is because water is becoming in short supply and more costly in many parts of the world [29].

Water efficiency measures can be reusing wastewater for flushing toilets, laundry, gardening and irrigation, and also car washing while on the technical side, it can be through dual plumbing to use rainwater harvesting, low flow showerheads, and ultra-low flush toilets [19]. However, it is asserted by [27] that it only makes sense to have rainwater harvesting if there is a rainfall of 50 mm/month for half the year on the minimum and 300 mm for a year. Policies are used to mitigate the water resource challenges by putting a legal framework in place to discourage resource waste and increase efficiency from supply through the demand process [30]. However, technological advancements are not sufficient if consumption grows, but a review of the user's habits and decisions is vital as it ultimately has a great effect on the water resources used by the product [31].

c. Resource Efficiency

Hertwich et al. [32] also stated that other resources can be saved for up to 50% from extracted material if there is better construction and use of buildings, and [33] posited that the target should be zero waste in planning, construction, use, and maintenance for GB. According to the City of Cape Town (CoCT) [34], using reusable and recyclable materials and systems would eliminate waste in construction and operations. CoCT posited that the system calls for a planning and design strategy that aims to mimic nature by reusing, recycling indefinitely, and using discarded resources in other systems nearby. Hence, waste management decisions are crucial during the design phase because that is where specifying materials that have minimal waste during the production of the material and will result in reduced waste during construction, maintenance, and demolition of the building [35].

The CoCT [34] suggested that subgrade for driveways can be made of building rubble, for example, rather than being dumped. Old doors and windows can be reused than using virgin materials to save on costs and environmental impact [34]. Providing waste compactors in projects where there is a lot of waste created will save landfill space and the transportation costs associated with waste removal [34]. Resource efficiency is sometimes referred to as the economic efficiency of using materials like biomass, fossil fuels, metals ores, and non-metallic minerals. They can be expressed as material productivity or intensity, and the two are opposite [36].

d. Indoor Environmental Quality

This criterion controls pollutants, moisture, and toxic material inside the house to improve the occupant's health [37]. Indoor environments have a significant influence on residence's wellbeing and productivity, especially features like the amount

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and quality of light and colour, the sense of enclosure, privacy, access to window views, sensory variety, connection to nature, and personal control over space conditions [34]. The CoCT [34] asserts that thermal comfort, visual comfort, indoor air quality, and natural lighting should be given consideration in the built environment. They dominantly influence occupants' health, comfort, and productivity in an indoor space [38].

Quality indoor environmental conditions should keep rain, snow, and wind out of indoor environments by providing and maintaining warm thermal conditions in seasonally cold climates providing cooler and more suitable conditions in hot climates [39]. Larger buildings must be mechanically ventilated to minimise odours and discomfort related to human bio effluents [39]. Nitmetawong et al. [40] state that being able to control thermal satisfaction and other parts of indoor environments needs the use of a variety of climate-control technologies and a commitment to operate them properly. According to Mujan et al. [38], 87% of the time, people these days and another 6% in their vehicles indoors. Indoor environmental quality does not have as much credit as it should from the regulations and standards in this field, but rather the emphasis is on low energy consumption and minimal impact of buildings on the environment [41]. Currently, the priority is on operating and rent costs and the performance of the building's operating parameters when evaluating. The new point of view seeks to approach this evaluation to include the health benefits to the occupants [42]. With an increasing number of social housings, it is important to implement effective mechanisms to mitigate poor indoor environmental quality because they contribute to negative, exacerbate existing health effects [43].

B. Drivers of GB Practice Implementation

Darko et al. [44] stated that there is an incentive from the public authorities for GB and in their identified that excellent public image, competitive advantage, cost savings, and improved productivity were the drivers for adopting GB. Developers are also motivated by public authorities to adopt GB. However, they are not convinced by political incentives to change their behaviour into implementing GB principles [19]. It is found that one of the important drivers for change is energy conservation, resource conservation, and water reduction [44]. Darko et al. [45] identified that the top six sustainable design and construction drivers are energy conservation, improved indoor environment quality, environmental/resource conservation, waste reduction, and water conservation. Though there are different sets of drivers for investors and tenants, the above mostly being for tenants, however, the company image and reputation and lower lifecycle costs were recognised as the most significant mutual drivers [44]. Chan et al. [46] showed that higher return on investment, enhanced marketability, lower lifetime cost, higher building value, and lower operational costs were the most important business drivers in the GB market. Other primary drivers for GB are cost reduction and market differentiation [47].

Investing in GB provides many business opportunities in the industry for every stakeholder and benefits customers or buyers from new jobs arising from the increased marketability of new green products [46]. Mondor et al. [48] demonstrated in their study that GB projects can speed up broader organisational sustainability efforts, investment in green systems can produce direct savings and better sustainability operations and maintenance practices, GB projects can influence their industry standards by putting a prototype for future design and construction, and also by enabling a culture of best practice sharing, benchmarking and peer comparison and lastly GB can make significant benefits for a region, including additional commerce [49]. Table I is detailed literature reviewed drivers for adopting green innovation.

TABLE I
POTENTIAL DRIVERS FOR ADOPTING GBTs

No	Driver factors	Sources
1	Improved productivity and efficiency in construction processes and management practices	[50]-[52]
2	Better workplace environment, Company image and reputation/marketing strategy; Attract premium clients/increase building value; Attract quality employees and reduce employee turnover	[53]-[55]
3	Greater energy-efficiency	[56], [57]
4	Preservation of natural resources and non-renewable fuels/energy sources; reduced construction and demolishing wastes; reduced use of construction materials and reduced environmental impact	[58], [59]
5	Improved occupant health, comfort, and satisfaction	[44], [54]
6	Greater water-efficiency	[12], [60]
7	Thermal comfort (better indoor temperature); Better indoor environmental quality	[45], [61]
8	Facilitate a culture of best practice sharing, commitment to social responsibility	[44], [45]
9	Set standards for future design and construction	[44], [45]
10	Reduced whole lifecycle cost	[44], [62]
11	High rental returns and increased lettable space	[44], [63], [64]
12	Improved performance of the national economy and job creation	[44], [45], [54], [65]

The review of past studies has identified a three-level classification of GB drivers for investors: external drivers, corporate-level drivers, and property-level drivers [44]. Gou and Xie [66] suggested generally that GB drivers can be grouped into five main categories; external drivers, corporate-level drivers, property-level drivers, project-level drivers, and individual-level drivers. Wang et al. [67] defined external drivers as events that happen outside the company that develops GB, such as United Nations (UN), government, European Union (EU), and clients/customers, to companies or organisations that build green. The corporate-level driver has been defined mainly by the image benefits of the company. Establishing a good reputation and image has become necessary for organisations to survive in their industries [44]. Andelin et al. [68] opined that the company's value reflects its corporate image and it defines the attractiveness of the company and its products in the market.

According to Darko et al. [44], property drivers can include increased property values, high rental income, and reduced risks and liability. Stakeholders such as tenants are increasingly demanding GB to minimise their environmental impact and occupancy cost, hence maximising the capital value of the building [69]. It is recognised that high operations and

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maintenance costs of buildings could be reduced by green design has driven the GB market over the years [44]. Project-level drivers that were identified during academic studies had limited empirical evidence, and this could be because most certified GB focus mostly on the operational aspects of the building than the construction phase, according to Arif et al. [70], which makes sense because most of the emissions and environmental impact are caused during the use phase of the building. The driving force is that decisions made at the project level affect the overall or final cost of building [44].

In psychological theory, motivation is understood as the force behind most human behaviour. Therefore, Murtagh et al. [71] opined that individual-level drivers are relatively fundamental and define what internally drives people to want to drift towards aiming for sustainability or to try GB practices on their projects. Darko et al. [44] identified the top 4 drivers at the individual level: moral imperative or social conscience, self-identity, personal commitment, attitudes, and traditions.

C. Barriers to GB Practice Implementation

There are still potential barriers to the growth of the green sector, including the public not understanding the industry and a lack of GB professionals [72]. Marco and James [73] opined that another barrier is the perceived high costs of implementing green technology solutions, which is less than most think and cheaper in the long run. The cost of GB is perceived to be more expensive than conventional buildings because green materials cost more than conventional materials [74]. Table II is based on some of the reviews of the contradiction between the perception of GB and the actual reality as captured by [19].

TABLE II
REALITY VERSUS PERCEPTION OF GREEN BUILDING [19]

Perception	Reality
The commitment required to build GB is too great.	It is possible to create GB.
The majority of contractors cannot use green building materials because they are not yet available and of inferior quality to conventional building materials.	Green products are just as durable as traditional ones.
Due to the high premium, green development is not financially feasible.	Throughout the lifecycle of GB, net costs are inherently lower than traditional development, especially when considering energy savings.
It would have been relatively simple if there had been greater demand for GB.	Due to the market's rapid growth, there is a demand for green development projects.

Masia et al. [19] argue that another factor that shows to have limited the implementation of GB principles could be a lack of practical knowledge and expertise among building owners. Moreover, Le Jeune et al. [75] reported that South Africa does not have enough projects in which designers can benefit from enough knowledge about green building design reinforcing this factor's importance to a more significant extent. Hankinson and Breytenbach [76] added that there were not enough clients or projects to allow designers to gain the needed experience in GB design. Hence, GB's lack of experience and expertise led to the quantity surveyors overestimating the initial cost premium [46].

Builder incentives act as an enabler in GB implementation at the initial stage, and due to legislative and institutional barriers, it becomes a challenge [77]. It is evident that most research is done during the initial decision-making stage about implementation barriers of GB because the operational stage is where savings and benefits occur, according to Ding et al. [77]. Time and cost in construction are closely related, and they are both as important when measuring project performance and success [44]. Darko et al. [44] opined that it takes longer for the construction team to decide when trying to fulfil green requirements for a project. This then delays pre-construction, and another timed challenge is the new green building technology (GBT) approval process within the firm [44].

Darko et al. [44] also mention that the lack of awareness, education, and information is also a highlight of being barrier because there is a tendency to maintain current practices and resist change. Some studies lamented that scarce and poor accessible information available on green products and high-performance building systems [76]. Then there is the social and psychological behaviour of stakeholders and their attitude towards intention to purchase, which affects GB's acceptance and progress [44]. Understanding that successful adoption of innovation needs effective cooperation and working together between stakeholders on a project; therefore, lack of communication and interest amongst the project team may affect the adoption of green innovation [44]. Table III, sourced from [44], provides factors taken from existing literature, listed in no particular order for GB barriers or have the potential to hamper the adoption of GBTs.

TABLE III
POTENTIAL BARRIERS TO GBTS ADOPTION [44]

- Fewer GB codes and regulations are available
- Conflicts of interest among various stakeholders in adopting GBTs
- High market prices, rental charges, and long pay-back periods of GBs
- The high degree of distrust about GBTs
- Lack of GBTs databases and information; knowledge and awareness of GBTs and their benefits; GB expertise/skilled labour; interest and market demand; promotion; tested and reliable GBTs; importance attached to GBTs by leaders; financing schemes (e.g., bank loans); availability of demonstration projects; reliable GBTs research and education; technical standard procedures for green construction; available and reliable GBTs suppliers and government incentives/support for implementing GBTs
- Insufficient GB rating systems and labelling programs are available
- Unfamiliarity and Higher costs of GBTs
- Implementation of GBTs is time-consuming and causes project delays
- Resistance to change from the use of traditional technologies
- Complexity and rigid requirements involved in adopting GBTs
- Difficulties in providing GB technological training for project staff
- Risks and uncertainties involved in implementing new technologies
- Limited experience with the use of non-traditional procurement methods

III. RESEARCH METHODOLOGY

This study employed a qualitative research strategy to provide the researcher with the perspective of the participants through immersion in a situation and as a result of direct interaction, with less structure-data gathering through, observations, content analysis, or interviews using some open-ended questions to explore. The target population was property practitioners like property owners, property managers, assistant property managers, real estate agents, leasing assistants, facilities managers, and maintenance officers in the residential apartments sector in Bloemfontein.

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Several residential apartments were identified in Bloemfontein and any person(s) who manages or maintains were purposefully sampled using the non-probability sampling method to collect information. The purposive sampling was selected because the characteristics and objectives of the study are known and we assume that the participants would bring the element that contains the most complex and rich information that will be the most valuable. Property owners, property managers, assistant property managers, real estate agents, leasing assistants, facilities managers, and maintenance officers were selected by using purposive sampling. The coded data (open-ended questions) were subsequently analysed together with the data collected from the closed-ended questions using descriptive statistics such as mean scores, percentages, ranking, and standard deviations. For this study, we used coding and categorising to analyse the data, manually interpreted the research results with the use of Microsoft Excel.

IV. Results and Findings

A. Demographic Information

The respondents' profiles regarding their demographic attributes, like gender, profession, registration with any national property associations, and years of experience in the property industry, are indicated in Table IV. As per Table IV, 80% of respondents were male, and 20% were female.

TABLE IV
PARTICIPANTS' DEMOGRAPHICS

Demographics		Frequency	Percentages
Gender	Male	28	80%
	Female	7	20%
	Total	**35**	**100%**
Profession	Property Developer	6	17%
	Property Manager	15	43%
	Facility Manager	5	14%
	Real Estate Agent	9	26%
	Total	**35**	**100%**
Experience in the property industry	0 - 5 years	2	6%
	6 - 10 years	6	17%
	11 - 15 years	8	23%
	Over 15 years	19	54%
	Total	**35**	**100%**
Professional body membership	Real Estate Business owners of South Africa	17	49%
	Institute of Estate Agents of South Africa	6	17%
	Estate Agency Affairs Board	5	14%
	Rental Housing Tribunal	7	20%
	Total	**35**	**100%**

Regarding the professional affiliation or position of the respondents in the property industry, the majority (43%) are property managers, followed by real estate agents at 26%. Most respondents (54%) have over 15 years of experience in the residential property industry, whilst all the participants have registered with their respective professional bodies, with the majority (49%) being members of Real Estate Business Owners of South Africa.

B. Knowledge of GB Principles

This question aimed to determine if the respondents were aware of GB principles. This question is the foundation of the rest of the following questions. The results in Table V show that most respondents know and are familiar with GB principles. 94% of respondents knew what GB principles are, and 6% did not know about them.

TABLE V
GREEN BUILDING PRINCIPLES' FAMILIARITY

Response	Frequency	Percentages
Yes	33	94%
No	2	6%
Total	**35**	**100%**

C. Knowledge of Green Star Certification

Table VI illustrates that 86% of respondents knew what green star certification whilst, 6% were unfamiliar with it, and only 8% were unsure. It can be deduced that most of the respondents have an insight into green star certification.

TABLE VI
KNOWLEDGE ABOUT GREEN STAR CERTIFICATION

Response	Frequency	Percentages
Yes	30	86%
Unsure	3	8%
No	2	6%
Total	**35**	**100%**

D. Possible Factors Inhibiting the Implementation of GB Principles in Residential Apartments

This question revealed why property practitioners hesitate to employ green principles in their buildings. Table VII shows what each of the 35 participants in the interview had to say about the barriers to GB adoption in the residential building sector. For the cost of green materials, 13% of the participants raised as a hindering factor, technical difficulties of construction processes of green technology were an issue for 14% of the participants, and 12% of the participants raised that there is no type of integrated green design contracts for green projects.

TABLE VII
FACTORS INHIBITING THE ADOPTION OF GB PRINCIPLES IN RESIDENTIAL APARTMENT DEVELOPMENT

Inhibiting factors	Frequency	Percentages
Cost of the materials	30	13%
Technical difficulties	33	14%
Contractual difficulties	29	12%
Time approval	35	15%
Resistant to change	20	8%
Performance of green materials	32	13%
High rental charges	34	14%
Lack of awareness	9	4%
Shortage of skills or expertise in GB	8	3%
Complex green building codes and regulations	8	3%
Total	**238**	**100%**

The lengthy approval process for advanced green technologies and sustainable materials was a concern for all

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participants; 8% of the participants are fixated on the traditional way of construction and are resistant to change. There was 13% uncertainty from the participants on how well green materials can perform when put to the test of harsh conditions. Over time, 14% of the respondents were concerned about high rental charges and long payback periods after implementing green technologies because they are expensive. Lastly, 9% and 8% of participants voiced other factors, like lack of awareness among the public about GB technologies, shortage of skills or expertise on GB, and complex green building codes and regulations, respectively. The fair distribution of the participant's responses indicates that they are aware of the common causes of poor adoption of GB practices in residential development.

V. Discussion of Findings

A. Implemented GB Principles in Residential Apartments

The findings indicated that even though property practitioners were aware of the GB principles, it had to be determined whether they had any of the principles incorporated in the properties they operated and only 20% of them had used. These participants were affiliated with residential property bodies and had less than 10 years of experience in the property industry. The most incorporated principle is energy efficiency 100% of the 20% of participants that had implemented it, used solar panels for lighting and water heating. GB tend to generate energy, thus minimising the usage of energy in the building and reducing the impact it has on the environment, and also contributing to reducing the operational costs [19]. The second most implemented technique is resource efficiency by recycling and reusing many materials they removed during renovations. Resources can be saved for up to 50% from extracted material if there is better construction and use of buildings. The target should be zero waste in planning, construction, use, and maintenance for GB [33]. Sustainable site development was another significant practice with 70% of the 20% of respondents adhering to it by providing permanent stormwater management in the yard and green space landscaping of trees and plants. Landscape engineering supports sustainable site planning and construction methods that minimise pollution and balance nature and built systems [78].

B. Factors Demotivating GB Principles in Residential Apartments

According to Darko et al. [44], many barriers exist to implementing GB principles in the residential property space. The question on common barriers was raised to participate to get their thoughts. Time of approval was the biggest issue for 100% of the participants echoing that the approval process for advanced green technologies and sustainable materials that need to be used are time consuming and lengthy. The lengthy approval process throws a challenge to the project team in developing the project schedule and the project's completion as per schedule. This then delays pre-construction, and another timed challenge is the new GBT approval process within the firm [44].

97% of participants stated that costly green material would increase rent for tenants who do not know or care about GB. According to [19], high market prices, rental charges, and long pay-back periods of GB is a barrier to adopting GBT. They just care about the convenience of things, which was mentioned in the 71% of other categories from respondents that there a is lack of awareness among the public about GBT. Le Jeune et al. [75] reported that South Africa does not have enough projects currently in which designers can benefit from enough knowledge about GB design to a larger extent. Then technical difficulties were another big issue raised by 94% of the participants on implementing GB, stating that green technologies require complicated techniques and construction processes, and if the complexities are not well addressed enough, then it may impact the project manager's performance.

VI. Conclusion and Recommendations

The lack of green residential apartments in South Africa, including the Free State Province, has not recognised the era of sustainable buildings for a better future. While facing the electricity shortage as a country, it is vital to find alternative means to supply energy and conserve more water to improve economic growth and quality of life. These are some of the essential principles that reflect on GB and impact the natural environment. Green building application is a cost-saving mechanism for property owners' post-construction. Yet, property owners are not enthusiastic about implementing GB principles in constructing their buildings. This study investigates why there is a deficiency in implementing GB principles in the city of Bloemfontein. Property practitioners were interviewed to find out why they are demotivated to implement green principle categories in their residential apartments.

The question on common barriers was raised to participants. Time of approval was the biggest issue for 100% of the participants echoing that the approval process for advanced green technologies and sustainable materials that need to be used are time consuming and lengthy. 97% of the respondents stated high rental charges for green properties, and 71% indicated a lack of awareness about GBT among the public. Then, technical difficulties were another big issue raised by 94% of the participants on implementing GB.

To optimise the adoption of GB principles in residential buildings in Bloemfontein from the results, the following strategies are recommended:

- Human settlements' government officials can be more confident and easier on approval processes of GB designs and construction processes.
- Municipal rates are to be lowered for residential buildings that have implemented GB principles so that rent to tenants does not hike up and that can be an encouragement for implementation.
- Regulatory standards are to actively market and recommend green materials over conventional materials, so there is performance confidence in green materials.
- There is a need for contractor training and development on construction processes and techniques.

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VII. Areas for Further Research

After conducting the research for this study, the following areas for further research can be explored:

- Further insights can be generated by researching human settlement government officials' knowledge base on GB.
- There must be a study on residential tenants' interests in GB properties.
- Further study should be done to test green materials' performance and ability to resist harsh conditions.

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