Barriers to the green retrofitting of existing residential buildings

Christopher Amoah and Jeanne Smith
Department of Quantity Surveying and Construction Management, University of the Free State, Bloemfontein, South Africa

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Abstract

Purpose – This study aims to examine the challenges for green retrofitting implementation in existing residential buildings to lower the running cost and achieve a better energy-efficient system.

Design/methodology/approach – This study adopted a qualitative approach by interviewing conveniently selected 16 construction professionals, made up of architects, quantity surveyors and engineers. Data received were analysed using the content analysis method.

Findings – The findings revealed that the main barriers to incorporating green retrofitting in the existing residential buildings as the nature of the existing structures, limited knowledge, not being a priority and high costs involved in the process. Moreover, other factors influencing property developers' decision to apply energy-efficient principles in a residential home include cost (initial capital and maintenance), level of knowledge, nature of the climate in the area, local legislation, more independence and increasing the property's market value and environmental aspect.

Research limitations/implications – This study is limited to South Africa; thus, the literature available was limited.

Practical implications – People's perceptions, either wrong or correct, affect their ability to make an informed decision to adopt green retrofitting principles, thereby denying them the opportunity to reap the associated benefits. Therefore, there is an urgent need for the construction industry stakeholders and government to increase educational opportunities for property owners on the importance of green retrofitting.

Originality/value – This study provides the occupants with the possible barriers and problem areas with implementing these principles. They will thus make an informed decision when implementing sustainable design methods.

Keywords Green retrofitting, Sustainability, Innovative technologies, Residential buildings

Paper type Research paper

1. Introduction

Residential properties' energy efficiency must be improved to mitigate the unavoidable effects of climate change and lower operating costs (Ling and Niig, 2016). Despite its substantial natural resources, Africa confronts tremendous hurdles in sustainable energy development. If approached correctly, it might not only meet its immediate requirements but also relieve global issues such as desertification, environmental degradation and greenhouse gas (GHG) emissions (Aliyu *et al.*, 2018). Much of the older homes are energy inefficient and not very sustainable. However, the only solution cannot be to demolish the house and rebuild it – it is simply not feasible. The answer lies in the refurbishment of the existing

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dwellings – which will lower the running cost and cause an overall increase in the sustainability of the houses (Wilkinson and Sayce, 2019).

South Africa is one of the top 12 carbon dioxide (CO_2) emitters globally, owing to its reliance on coal for power production and its energy-intensive manufacturing and mining industries. GHG emissions amounted to 579 million tonnes of carbon dioxide equivalent (CO_2e) in 2010 (Wolpe and Reddy, 2015). With an average of 2,500 h of sunlight per year and radiation intensity of 4.5–6.6 kWh/m^2, South Africa is among the top three countries in the world. Wind power potential in South Africa is predicted to be 67,000 GW, comparable to solar energy (Jain and Jain, 2017). Urban regions now house 55% of the world's population and consume about 75% of the world's significant energy supply. By 2050, with this rate of exponential urbanisation, 68% of the global population will be living in cities (Ritchie and Roser, 2019). According to the 2018 Sustainable Development Report, 91% of the urban population in 2016 breathed air that did not meet World Health Organization air quality standards. Again, over 50% of the urban population were exposed to air pollution levels 2.5 times higher than the safety norm, and air pollution was responsible for over 4.2 million deaths. Since 2007, cities have been home to more than half of the world's population, accounting for about 75% of global resource consumption. This trend will continue throughout Africa over the next decade because of increasing urbanisation rates (Madlener and Sunak, 2011).

The property industry is proven to have a significant environmental effect, generating up to 50% of CO_2 emissions, 71% of power consumption, 16% of water consumption, 50% of raw materials, 40% of solid landfill trash and 40% of energy demands (Atkinson, 2007; Keeping *et al.*, 2007). Urban infrastructure and utilities would also need to grow significantly to meet this considerable population growth, which would lead to a massive rise in energy demand. Electricity is the world's second-largest energy source, accounting for around 19% of global energy demand (Chowdhury *et al.*, 2020). Therefore, it is paramount to ensure a sufficient electricity supply in an environmentally sustainable way. Given urban areas' total dominance over global energy use, achieving these sustainability targets would largely depend on urban energy's current and future dynamics (Chowdhury *et al.*, 2020). Various factors, such as demography, environment, economy and construction regulate local electricity use patterns (Chowdhury *et al.*, 2020).

The increasing cost of operation and the energy shortage is some of South Africa's biggest problems. A big part of the housing district was built when operational costs and energy shortages were not critical. On the other hand, the rapidly rising costs of labour and materials in construction brought up whether or not the energy saved after the improvements justify the money spent on the upgrades (Chan, 1980). The key issues pertaining to energy inefficiency in existing residential homes can be addressed by first determining what contributes to the energy inefficiency factor of the home and how it can be modified to improve the running cost. Even though there is uncontroversial evidence that modern energy-efficient buildings have improved energy consumption levels and post-construction maintenance costs, there is indisputable empirical evidence that the application of energy-efficient mechanisms in residential buildings in South Africa is too low, resulting in high running costs. The study's specific objectives are:

- to identify the factors that influence the application of the energy efficiency of a residential home; and
- to determine why residential building developers find it challenging to incorporate energy-efficient mechanisms.

The study gives an insight to construction industry stakeholders regarding possible challenges facing the implementation of green building principles in residential buildings.

Thus, policymakers can make an informed decision when formulating strategies regarding sustainable designs.

2. Literature review

2.1 Concept of green retrofitting

Buildings are now viewed as a continuously changing organism that must be processed, rehabilitated and transformed throughout time to meet the user's requirements specified at a certain point. Buildings are at the heart of the European Union's (EU) energy efficiency measures, accounting for over 40% of final energy consumption and 36% of GHG emissions. Around 75% of buildings are inefficient in energy use (European Commission, 2020). According to recent applications and research, green retrofitting has improved energy efficiency, improved building performance, increased tenant happiness, and increased economic return while lowering GHG emissions (Al-Kodmany, 2014). Retrofitting refers to changing the systems or structure of an existing building after its initial construction and occupation, while green retrofitting refers to the change in the existing building to make it more environmentally friendly, reducing negative impacts and reducing operating costs. Green retrofitting existing building stocks is necessary to meet national energy efficiency goals, achieve climate change's medium and long-term objectives and shift towards a sustainable, low-carbon economy by 2050 (European Commission, 2020).

By making a substantial contribution to the EU's energy use, traditional energy use and CO_2 emissions, including a variety of factors that may adversely affect the health of the occupants, the building sector targets numerous medium- and long-term policies and strategies to minimise the negative impact on the environment. An example of such a policy is one started by the EU, which is named the 20–20-20 target, which has the following aims:

- reducing the EU's GHG emissions by 20% relative to 1999;
- increasing the share of energy derived from renewable sources in the EU by 20%; and
- improving the EU's energy quality by 20% (European Commission, 2020).

The Green Retrofit Design (GRD) goals are improving energy efficiency and reducing carbon emissions in existing buildings to be retrofitted sustainably. There is a clear distinction between architects and engineers at the pre-design stage as architects have minimal understanding of energy models, but engineers use them to save energy. On the other hand, architects and engineers are tasked with developing environmentally friendly and resource-saving construction methods (Shanshan and Geoffrey, 2013). When developing a GRD, the present condition of a building is taken into account for energy modelling, variation advantages and compliance with statutory requirements. GRD can give technological solutions to existing building energy concerns, such as rainwater reuse, energy-saving air conditioning and heating, shading technology, roof ground insulation technology and lighting system changes (Shanshan and Geoffrey, 2013).

2.2 Application of green building techniques in residential properties

According to Smith (2015), retrofit efforts are focused on energy, water usage and waste output. Light-touch retrofitting, such as installing energy-efficient lighting and controls, building services, and management systems and controls, may save up to 40% on annual energy expenses. Furthermore, water and garbage recycling (for example, in shopping malls, workplaces, schools and public buildings) will have a significant and favourable impact on cost and sustainability (Khairi *et al.*, 2017). The introduction of green building standards and practices has restricted documented progress cases in the South African context. Nevertheless, South Africa has been experiencing growth in adopting green practices by different professionals in the built environment. The use of sustainable materials and the introduction of green construction practices have increased the energy efficiency of a building, lowered energy costs and reduced maintenance and operational costs (Senick, 2011; Modise, 2018).

Sustainability principles that rest on the premise of resource or energy-efficiency improvements due to technological advancements tend to neglect the behavioural responses evoked by technological advances and miscalculate the potential savings effect. Many theories of sustainable development stress the role of technological advancing efficiency improvements. Technology is supposed to assist us in promoting a society in which we can maintain or even improve our current standard of living while using fewer resources, especially energy. These ideas are based on the assumption that a 1% improvement in productivity would, on average, result in a 1% reduction in resource consumption. However, as technological advancements elicit behavioural reactions, this rarely happens. Sometimes, an increase in efficiency of 1% can lead to resource use of much less than 1%, and in other scenarios, it can even lead to an increase in resource use – a concept known as the rebound effect amongst energy economists (Binswanger, 2001).

As defined by Wei and Liu (2017), the rebound effect occurs when actual reductions in energy usage and emissions are fewer than the projected reductions generated by improved energy efficiency due to induced behaviour adjustment of key economic actors. They created a scenario of energy efficiency improvements using a global computable general equilibrium model, which was then compared to a business-as-usual scenario to determine the global rebound impact. Their estimates suggest an enormous rebound impact on energy demand of 70% and corresponding emissions of 90% by 2040, with regional and sectoral differences.

2.3 Green building measurement criteria

The Green Globes grading system was initially used in the USA in 2004 to encourage green building techniques in new construction and ongoing renovations of existing structures. Green Globes-NC and Green Globes are two green construction initiatives in Canada. This rating may be obtained by acquiring one to four globes, with 350 and a maximum of 1,000 points. Project management (policies and practices), site, energy efficiency, consumption, water, resources, building materials, solid waste, carbon emissions and associated risks, indoor air quality and atmosphere are among the Green Globes Environmental Assessment Areas. Some regulatory organisations in the USA require buildings to be Green Globes certified (Durmus-Pedini and Ashuri, 2012).

In the USA, the Leadership in Energy and Environmental Design (LEED) rating system is used. This rating system classifies green initiatives into six categories: sustainable sites, water efficiency, energy and environment, materials and resources, quality of the indoor environment and design process creativity [United States Green Building Council (USGBC), 2018]. All these categories are graded in a house, and then all the various scores are added together to create one building score rating out of 69. A specific grade in the certificate will then be given for the final score out of 69, either bronze, silver, gold or platinum, which is the highest qualification (USGBC, 2018).

The Green Building Council South Africa (GBCSA) (2017) offers an objective measurement for Green Buildings for the commercial property industry. It acknowledges and rewards environmental leadership in the property industry, ranking in nine categories, including management, quality of the indoor environment, energy, transport, water, materials, land use and ecology, pollution and innovations. A construction development will earn either a 4-star rating indicating that it has used best practice and a 5-star rating honouring "South African Excellence" or the prestigious 6-star rating, suggesting a world leader (Green Building Council South Africa, 2017).

2.4 Benefits of green building

A benefit can be described as "something that aids or promotes well-being" – which can be seen as one of the main aims of green buildings, as it usually relates to the environment, health and community (General Services Administration [GSA], 2008). The advantages of green buildings are grouped into four primary divisions, according to a GSA research done in 2008: environmental, health and community, financial, market and industrial; however, most of the categories include secondary economic benefits. Furthermore, when compared with national norms, green buildings produced 33% fewer carbon emissions, had a 27% better occupancy satisfaction, used up to 45% less energy, had 13% lower aggregate maintenance costs and used up to 54% less water (General Services Administration, 2008).

Another research by Leonardo Academy claimed that buildings with LEED-EB certificates saved a lot of operating costs. In comparison with conventional buildings' maintenance costs, LEED-EB compliant buildings saved an average of $6.68 per square foot while incurring only a $2.43 per square foot expense loss to comply with LEED-EB requirements, according to data from the Building Owners Managers Association International Experience Exchange Study (Leonardo Academy Inc, 2006). According to research done in the Sri Lankan construction sector, the cost associated with new green buildings is 28% greater than a conventional structure. The life cycle expenses of these buildings, on the other hand, were 24%–28% cheaper than a typical building (Weeranghe *et al.*, 2017).

Green buildings, long dismissed as too expensive, have seen increased popularity due to their many benefits over non-green buildings that vary from environmental to social and economic. Eight reasons to incorporate green design principles into your construction (Nationwide Construction, 2016):

(1) Low maintenance and operative costs due to the incorporation of unique features that ensure the efficient use of resources such as water and energy.

(2) Energy efficiency, because the designers of such buildings try to steer away from the dependency on energy from non-renewable sources such as coal.

(3) Enhances the indoor environment quality by installing operable windows that allow as much sunlight as possible and omitting elements dangerous to the occupant's health.

(4) The green design encourages the use of renewable water sources, such as rainwater, to minimise water waste by installing effective plumbing fixtures and reducing the strain on shared water supplies by installing water purification and recycling systems.

(5) People who live in green buildings enjoy many health benefits because of the safety of materials used in constructing such buildings. Eco-friendly building firms, for instance, stopped using plastic by-products that have been found to release harmful materials.

(6) Material efficiency includes the use of physical processes and materials to enable materials to be used to a minimum without losing the quality of the product; therefore, processes should create as little waste as possible. Green building companies use long-lasting materials to achieve material quality, recycle and reuse

some products, construct buildings in ways that enable fewer materials to be used and use processes that use less water, raw materials and electricity.

(7) Green buildings help keep the environment safe by reducing energy sources that pollute the environment, such as coal.

(8) Local shared resources such as water and electricity come under considerable strain as the population increases. Green buildings can reduce this strain by using technologies and processes that increase water and energy efficiency (Nationwide Construction, 2016).

3. Methodology

3.1 Research approaches

Research approaches can be explained as the processes involved in research – it spans from broad assumptions to detailed data collection methods, analysis and interpretation. To choose the approach best suited for the particular study, certain elements need to be taken into consideration, such as the nature of the research problem, the researcher's personal experience and, lastly, the audience of the study (Jansen and Warren, 2020). The approach used for this study is a qualitative approach using interviews. This specific method is to gain information from industry professionals who have gained years of physical experience working within the particular field of sustainability. The purpose is to explore these specific individuals' views, experiences, beliefs and/or motivations on green retrofitting and green building principles. An interview is the best suited, as the interviewees can elaborate on specific questions or statements with which he/she may disagree. Interviews are an appropriate method because verbal and non-verbal communication such as body language can be picked up. It helps to capture the emotion and behaviours of the interviewee, and an interview is an excellent way to ensure accurate and in-depth answers (DeFranzo, 2020). In comparison with online surveys, interviews allow more accurate screening of the participants. The interviewer is the one who is in control of the interview, and it forces the interviewee to stay focused, unlike online surveys (DeFranzo, 2020).

3.2 Target population and sampling method

The target population can be defined as the group of individuals that the study intends to research and draw conclusions from (Barnsbee *et al.*, 2018). In this instance, the target population will be architects, engineers and quantity surveyors in South Africa willing to participate. The purpose is to locate industry specialists with at least five years of experience in the sustainable building business. When researching a group of people, also known as the population, it is impossible to interview each person; thus, a sample representing the population is chosen to participate in the study. The researcher's responsibility is to ensure that the sample represents the same characteristics as the population (McCombes, 2021). A non-probability sampling method was best suited for this study, specifically convenience sampling. After the industry professionals had been identified, the convenience sampling method was used to interview 16 readily available participants prepared to participate in the study (McCombes, 2021). The researchers then contacted the identified participants about their willingness to partake in the study via email and telephone calls and arranged for interview dates. According to Leedy and Ormrod (2015), a sample size of 5–25 is adequate for a qualitative study among a homogeneous population. A study by Hennink *et al.* (2017) used 15 participants and reached a saturation point at the 9th interviewee, whilst Amoah and Simpeh (2021) reached a saturation point at the 14th interviewee from 19 participants. In this study, a saturation point where no new information emerged was realised at the 12th interview.

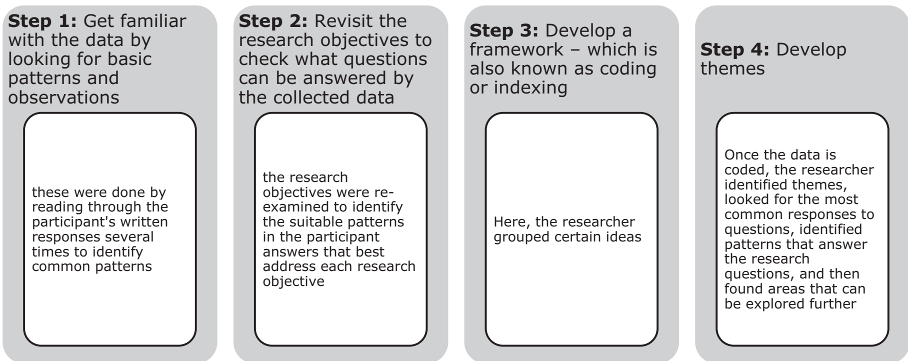
3.3 Data collection techniques

The interview questions were formulated based on the study's objectives and having extensively studied related literature. The intention was to identify the underpinning barriers for green principles implementation in residential properties; thus, the questions were formulated in an open-ended manner to seek the in-depth opinions of the participants. The interviews with the selected participants were conducted in person and telephonically, where the participant was not available for physical interactions. If the participant also does not want to conduct the interview telephonically, the interview question was emailed to him/her. The benefit of using an interview method is that it allows the interviewer to prepare questions ahead of time; however, it still leaves room for the follow-up questions during the interview. It allows for a more relaxed environment where the interviewee feels safe to express their own opinion regarding the topic, and it can provide reliable, comparable qualitative data (Cohen and Crabtree, 2006). Interviews find a balance between the two ideas, where several key questions can drive the process and allow the interviewer and interviewee to stray from the main idea and pursue another idea in more detail. The flexibility of this approach allows for the discovery of information by the interviewer that he/she may not have known of before (Gill *et al.*, 2008). Each interview took about 35–40 min.

3.4 Data analysis method

The content analysis method was used, and it is the most common method to analyse qualitative data. It is used to analyse documented information in texts, media or even physical evidence (Bhatia, 2018). Content analysis was performed following the steps proposed by Bhatia (2018). Thus, the qualitative data analysis steps adopted are shown in Figure 1.

In ensuring the validity and reliability of research, the guidelines proposed by Noble and Smith (2015) were followed. Thus, the researchers meticulously performed record-keeping and ensured that the interpretation of data was consistent; sought out similarities and differences across all data to ensure that all perspectives have been covered, and demonstrated transparency in terms of the thought processes during the data analysis. To conceal the identity of the participants, the following code, as indicated in Table 1, was assigned to all the participants during the data analysis process.



Source: Adopted from Bhatia, (2018)

Figure 1.
Steps in thematic data analysis

The demographic features of the participants are as follows:

From the demographic features stated in Table 2, most participants (38%) are in architectural practices, 69% are males and 69% have registered with their professional bodies. Again, most (44%) have over ten years of experience in sustainable construction; thus, their opinions on the topic are very valuable. Most (44%) of them have honours

Participants	Assigned codes
Quantity surveyors consultants	QS-R1, QS-R2, QS-R3, QS-R4, QS-R5
Architectural practice	A-R6, A-R7, A-R8, A-R9, A-R10, A-R11
Engineers consultants	E-R12, E-R13, E-R14, E-R15, E-R16

Table 1. Participant's codes

	Frequencies	(%)
Organisational types		
Quantity surveyors consultants	5	31
Architectural practice	6	38
Engineers consultants	5	31
Total	*16*	*100*
Gender		
Male	11	69
Female	5	31
Total	*16*	*100*
Professional body registration		
Yes	12	75
No	4	25
Total	*16*	*100*
Involvement in a retrofitting project		
Yes	7	44
No	9	56
Total	*16*	*100*
Years of experience		
0–5	4	25
5–10	5	31
10 and over	7	44
Total	*16*	*100*
Educational background		
National diploma	1	6
Bachelor's degree	7	44
Honours degree	4	25
Master's degree	3	19
Doctoral degree	1	6
Total	*16*	*100*
Location of participants firm		
Free State	1	66
Western Cape	4	25
Gauteng	11	69
Total	*16*	*100*

Table 2. Participants' demographics

degrees, whilst most (69%) are in Gauteng. The majority of the participants (56%) have not been involved in retrofitting existing buildings before, indicating a lack of application of green retrofitting in South Africa among the construction professionals and within the construction industry.

4. Findings

4.1 Participants' views on the factors influencing the application of energy efficiency and sustainability in residential homes

The first question sought to determine the participant's sustainability and energy efficiency knowledge within a residential home. This question refers to the factors that may influence the application of energy-efficient measures within a residential home from a home owner's perspective. Each participant has the opportunity to state two of the factors that they may have found the most important. Table 3 demonstrates each participant's two main reasons they think influence energy-efficient installation in a residential home. As observed from Table 2, 12% of the participants believe that climate in an area contributes to whether or not a homeowner installs energy-efficient measures as some climates are more feasible for some measures than others. In addition, 18% of the participants consider lack of knowledge as the factor. Many homeowners feel that they are not informed enough to install energy-efficient measures within their homes. However, it is not only the client's knowledge but also the lack of knowledge from professionals about green measures. Another factor that 12% of the study participants believe is that local legislation impacts the adoption of energy-efficient measures. The most significant influence as to why people are hesitant to install energy-efficient measures within their home, as cited by 35% of the participants, has to do with the initial capital expenditure of installing the system and the maintenance thereof.

Furthermore, 12% of the participants stated that they believe people want to be more independent from the local government in terms of services. With the local government not always consistent with their energy supply, many believe that being self-reliant is a more consistent way of living. Furthermore, only 9% of the participants think of the property's market value once all the energy-efficient measures have been implemented and believe that these systems can increase the property's market value. Lastly, only 3% consider the positive impact these energy-efficient systems will have on the environment and the carbon footprint.

4.2 Participants' views on the barriers to green retrofitting of existing residential buildings

This second question aimed to establish what barriers/challenges the participant links to green retrofitting. The most important barrier identified by the participants is represented in Table 4. Half (50%) of the participants agreed that working with an existing structure is

Table 3. Factors affecting the application of the energy-efficient measures in existing residential buildings

Question	Responses	Frequency	(%)	Ranking
In your opinion, what influences the application of energy-efficient measures in a residential home?	Cost (initial capital and maintenance)	12	35	1
	Knowledge level	6	18	2
	Climate	4	12	3
	Local legislation	4	12	3
	More independence	4	12	3
	Increase market value	3	9	4
	Environmental aspect	1	3	5
Total		*34*	*100*	

always difficult. Incorporating the old building with the new development is always difficult because one does not know if the old structure is sound enough to handle the further modifications.

The total construction of a new sustainable residential property may be more viable than retrofitting the existing building. Again, 13% of the participants stated that the most significant barrier to green retrofitting is the lack of knowledge among the professionals and contractors who must install the system. Further, 31% of the participants reported cost as the most significant barrier to green retrofitting. Lastly, one participant mentioned that green retrofitting is not a priority to homeowners and developers.

5. Discussion

5.1 Factors affecting the application of energy-efficiency measures in existing residential buildings

As illustrated in Table 3, the participants identified factors that influence the application of energy-efficient measures within a residential home as initial capital expenditure, knowledge level, climate, local legislation, more independence, increased market value and environmental aspect. The highest-scoring factor identified by the participants was cost – not only the initial capital expenditure of installing the system but also the maintenance thereof. Participants believe that homeowners perceived the amount to spend on green retrofitting their buildings; thus, they do not consider them in their new development, not their already built houses.

This view was echoed by A-R6 as follows:

> Some clients see and understand the benefit and savings in the long run, however, other clients see it as an unnecessary lump sum expense. Retrofitting homes are expensive and there always comes the stage in the construction process where costs need to be cut, unfortunately, the non-aesthetic elements are the first to go.

The issue of cost influencing homeowners' decision to green retrofit their homes was also identified by Weeranghe *et al.* (2017). They opine that although green retrofitting will save building owners about 24%–28% cost in the long run compared with the conventional structure, the initial installation cost influences their judgement in its application in the existing and new building construction. Again Nationwide Construction (2016) suggests that in spite of the low maintenance and operative costs of green retrofitted buildings, developers struggle to incorporate them in the buildings because of their perceived substantial initial cost. Again, the climate of an area was raised as an influencing factor for green retrofitting application by homeowners. Participants believe that climate-related benefits in an area, such as rainfall, may influence homeowners to retrofit their homes to include rain harvesting mechanisms.

As perfectly stated by QS-R16:

Question	Responses	Frequency	(%)	Ranking
What are the challenges concerning green retrofitting of the existing residential buildings?	Existing structures	8	50	1
	Costs	5	31	2
	Knowledge	2	13	3
	Not main priority	1	6	4
Total		*16*	*100*	

Table 4. Barriers to green retrofitting

> Rain water harvesting will not be as successful in the Karoo as Kwa Zulu Natal with a much higher rainfall.

The Intergovernmental Panel on Climate Change stated that GHGs could change the global climate. According to Ling and Niig (2016), to mitigate the effects of climate change and lower the operating cost of residential properties, the residential market's energy efficiency must be improved. The main focus of green buildings are resource efficiency, life cycle effects and building performance (Kwok *et al.*, 2011); however, environmental aspects ranked last (seventh) when asked by participants what influenced the application of energy-efficient mechanisms. Again, factors encouraging the exponential implementation of green buildings, including the increasing importance of environmental issues, the constant demand for progress on architectural environment quality, the emergence and growth of a variety of green building technologies and the gradual adoption of subsequent "green building evaluation criteria" have been mentioned by Zhang *et al.* (2011). However, the results of this study do not agree with the importance of the environment as a significant factor for instituting green building measures because the environmental aspect was mentioned the least among the participants. The results also show that a lack of knowledge of available systems influences one's capacity to accept green retrofitting properties.

As A-R11 states:

> At times the clients have knowledge about the possibility of retrofitting their buildings to incorporate green and energy efficiency mechanisms and they are not will to accept it.

It has been suggested that community members' involvement in green building practices and initiatives helps save the environment and apply these principles in their homes and office (Ecolution Consulting, 2018). However, these practices will be challenging to achieve if people lack knowledge about the entire concept of green retrofitting. Also, building owners are influenced to apply green building principles when renovating or building new residences due to complying with building legislation. According to World Green Building Council (2020), the green retrofitting of a residential home helps achieve many objectives for sustainable development. As such, government policy must embrace it if the achievement of sustainable development goals is to be realised.

As A-R8 proclaims:

> With the new construction of new buildings, certain elements with regards to energy efficiency are now compulsory as stated in SANS 10400-XA.

QS-R16: states

> Yes there are certainly benefits – these include: service cost to reduce from service providers, you can eliminate problems such as Load shedding, and water harvesting reduces cost and helps in time of drought. R-values can be made better to add in livelihood.

Newell (2009) suggests that the authorities have implemented sustainable legislation at the international, regional and local levels to help tenants, owners, developers, investors and the community embrace sustainability. Again, according to the participants, homeowners may embrace the green building principle to reduce their dependency on energy or water supply from the government. This is particularly so because of the current state of energy supply, where intermittent light out is rampant in South Africa. Bizikova *et al.* (2013) state that energy security includes consistency of energy supply relative to demand, physical availability of supplies and adequate supply to meet demand at a given price. Water security is the access to water, the safety of water and water affordability so that every person can lead a safe, healthy and efficient life while maintaining the preservation and protection of the natural environment. These findings imply that in spite of the hugely inefficient energy systems, waste production, emission of many pollutants and GHGs of existing building structures (Howe and Gerrard, 2010), homeowners are still adamant about green retrofitting and the application of energy-efficient principles because of the reasons enumerated.

5.2 Barriers to the incorporation of energy-efficient mechanisms

The barriers to implementing energy-efficient mechanisms by developers, as indicated in Table 4, are the nature of the existing structures, costs, lack of knowledge and not being the main priority. Participants believe that developers fail to incorporate energy-efficient measures because the buildings were initially constructed. Homeowners are discouraged from incorporating green building principles because their buildings were constructed long ago, and perhaps modifications may adversely affect the structure of their existing buildings. Others believe homeowners think their buildings are too rigid for improvements to allow for green and energy efficiency practices. Again, contractors may not install these features correctly, which may affect the structural soundness of their properties.

QS-R16 elaborates:

> The main structures are fixed which limits construction changes and can contribute to extra costs. Directional challenges may also occur with existing buildings, for example, solar panels might not be installed at the correct degrees and directions on existing roofs.

The respondents also mentioned the cost of green retrofitting existing buildings as one of the main barriers. Developers believe that it is too expensive to modify already constructed buildings to allow for green and energy-efficient mechanisms. According to Shanshan and Geoffrey (2013), when developing a green retrofitted design, the present condition of a building is taken into account for energy modelling, variation advantages and compliance with statutory requirements. However, these may create concerns regarding rainwater reuse, energy-saving air conditioning and heating, shading technology, roof ground insulation technology and lighting system changes. Again, Davis (2001) stated that builder incentives are one of the main reasons developers do not incorporate energy-efficient measures in a property. In spite of these previous concerns in the literature, the nature of the existing buildings inhibiting the green retrofitting seems to be a unique finding, scarcely found in the literature.

As E-R1 elaborates:

> It is difficult to keep up to date with all the new technologies that can be applied – as well as the knowledge of the available systems and the installation thereof.

A-R7 also states:

> Energy efficient measures have not yet been developed to such an extent that competes with existing building methods in terms of cost.

These findings collaborate with the Environmental and Energy Study Institute (2019). They stated that building designers are looking to optimise building efficiency in existing residential properties by incorporating renewable energy technologies and sustainable methods; however, it can be a timely and expensive endeavour. Saad and Mustapha (2016) also identified the cost and lack of knowledge as significant barriers to implementing green principles in South Africa. Samari *et al.'s* (2013) study in Malaysia identified barriers such as lack of credit resources to cover the upfront cost, risk of investment, lack of demand and a higher final price. Green retrofitting of existing building stocks is necessary to meet national energy efficiency goals, achieve climate changes and long-term objectives and shift towards a sustainable and low-carbon economy by 2050 (European Commission, 2020). However, the cost involved creates a challenge to the developers, thus depriving them of these stated benefits.

The issue of green retrofitting and application of green principles not being the main priority to the developers and lack of knowledge among developers and contractors about green principles also surfaced during the interview. According to the participant, developers do not think about green and energy-efficient mechanisms during the construction, perhaps because of the perceived high cost. Again developers, in most cases, do not have adequate knowledge about the importance of green energy; thus, they do not think about it. In most cases, the contractors constructing the facility may also lack the capacity to execute the green principle mechanism; accordingly, they become oblivious to the necessity of advising the client.

A-R6 states:

> Generally, from the outset, developers do not plan to implements sustainable mechanisms in order to keep the costs as low as possible. Most developers see it as unnecessary costs that effect their profit margin depending on the economic target group that the developer is catering for.

According to A-R8:

> Knowledgeable contractors that can be trusted are also not as available to execute these seemingly small projects.

Cost and budget run hand in hand, and for a developer who works on a budget and wants the most considerable possible margin for profit, the energy-efficient mechanisms are not his priority. Davis (2001) and Saad and Mustapha (2016) identified another barrier to green retrofitting as a lack of product knowledge. It is also interesting to note that developers' lack of priority on green retrofitting and green building principles is an emerging barrier identified by this study. Researchers' many benefits of green retrofitting, including energy cost reductions, are estimated to be 25%, with the Home Energy Rating System index falling by 34% (Mcllvaine *et al.*, 2013). Again the use of sustainable materials and the introduction of green construction practices have increased the energy efficiency of a building, lowered energy costs and reduced maintenance and operational costs (Modise, 2018). However, the findings of this study imply that the homeowners are deprived of the benefits mentioned above because of their perceived high cost, lack of knowledge and being afraid of the existing building's capability to withstand the green building modifications.

6. Conclusions and recommendations

The study identified that residential homes with better energy-efficient systems have some benefits, such as reducing maintenance and running costs. Nonetheless, cost, knowledge level, climate, local legislation, more independence, increased market value and environmental aspects are the determinant factors influencing developers to accept and apply energy-efficient measures in their existing buildings. Also, the application of energy-efficient mechanisms in existing residential buildings is too low because of perceived high cost, lack of knowledge, not making green retrofitting a priority and being afraid of the capacity of their existing buildings to withstand green building principles modifications. To optimise the adoption of green retrofitting systems in existing residential properties, it is recommended that firms should consider investing in research and development programmes to inform cost professionals and designers of the techniques available. The client should be informed of all the options available. The government should be involved in research and development programmes to support property owners and developers. Designers and cost professionals should play a more active role in encouraging green retrofitting projects. The government should particularly institute incentive instruments such as structural incentives, subsidy, and rebate programs, tax incentive schemes, low-interest mortgage loans, voluntary rating systems and business and technology assistance to enhance the appetite for green building implementation. The limitation of the study is that participants were drawn from South Africa; thus, the findings may not apply to other countries. Future studies should look into the measures and incentives instituted by the government to encourage the implementation of green principles by developers.

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Corresponding author
Christopher Amoah can be contacted at: amoahc@ufs.ac.za