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Identification of Constraints on Utilizing Energy-Efficient Technological Innovations in South African Warehouses

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Abstract

The pandemic significantly impacted the rapid increase in e-commerce activities, which led to many companies in South Africa needing to develop more prominent and sophisticated warehousing facilities. However, due to the current condition of South Africa's energy supply, the warehousing industry faces many challenges as regular load-shedding interrupts operations. Furthermore, energy-efficient innovative technologies used to reduce energy consumption in warehousing facilities are not widely adopted in South Africa. It was discovered that energy costs contribute a lot to warehouses operating budgets; therefore, the need for energy efficiencies in warehouses is essential. Certain technologies are readily available to be incorporated into South African warehouses to reduce energy consumption. However, implementing such innovative technologies will face many challenges and barriers. This research attempted to identify the challenges and barriers through a constructivist paradigm. The research was conducted using interviews with professionals with vast knowledge and experience in the warehousing industry. The data collection took the form of semi-structured interviews, where a qualitative data approach was adopted. Nvivo was used to generate underlying emerging themes. It was found that only a select few energy-efficient innovative technologies are adopted in South African warehouses and that implementing them provided numerous advantages and disadvantages. Most importantly, the findings revealed a significant number of challenges and barriers to the implementation of such technologies.

Keywords

Challenges, Energy efficiency, Innovative Technology, Warehousing Facilities.

1. Introduction

The warehousing industry is experiencing an opportunity to grow due to the growing popularity of e-commerce, which also boosts the demand for larger warehouses or warehouses with innovative technologies (Rode and Lamprecht, 2021). Due to the pandemic, online retail market growth has accelerated drastically as more people use online platforms to purchase goods. Expanding this industry will result in a greater demand for energy supply; therefore, energy-efficient innovative technology is critical to keep up with increased energy demands. Warehouses may be seen as a burden due to the required capital and operating expenses. According to Martins et al. (2020), warehouse operations represent approximately a quarter of the total logistics cost in the supply chain. Therefore, companies always look to reduce costs and improve energy efficiency in their warehouse operations. Finding the correct balance between using innovative technology to meet tenants' needs and using technology to eliminate the warehouse burden and reduce costs is becoming more critical (Kembro et al., 2017). In recent years, the warehousing sector has been reluctant to adopt energy-efficient innovative technology. Still, due to increasing competition in the industry and cost pressure, technology must be incorporated to gain a competitive advantage. Intelligent Sensors, the Internet of Things (IoT), Artificial Intelligence (AI), Building Management Systems (BMS) and Digital Twins are considered effective means to tackle those problems (Noran et al., 2019).

Implementing these innovative technologies to improve energy consumption addresses the current problem of a lack of environmentally sustainable warehousing (Noran et al., 2019). This is a problem in the South African context as there are national issues regarding energy supply. Therefore, increased effort needs to be put into building energy efficiency. South Africa faces the major problem of load shedding, which costs the economy R20 billion a month

(Akinbami et al., 2021). In addition to load shedding, increased energy prices are causing the cost of production and general building operations to increase. One way of developing sustainable warehouses is through renewable energy sources. A solar warehouse can be developed where the roof of the building is covered in solar panels, reducing energy costs and reducing carbon emissions (Botztepe and ÇEtİN, 2020). Furthermore, alongside the introduction of solar panels, next-generation of building and energy control such as intelligent BMS systems and digital twins can be used to improve energy efficiency. Beyond adding additional sensors and measuring and control systems, innovative technologies can help a warehouse manage energy output. However, the persistent issue is that very little research has been conducted investigating the potential benefit these innovative systems can have in South African warehouses. Thus, this study aims to provide a deep understanding of constraints and challenges in adopting energy-efficient technological innovations to improve the efficiency of South African Warehouses.

2. Literature Review

South African warehouses do not incorporate a wide level of technology, and the technology used is still relatively basic (Magoro, 2019). A key reason is that the South African workforce has not been trained to work with innovative technology. Therefore, the level of highly advanced technology in warehouses in South Africa has not been fully explored yet. As a result, some warehouses will gain a competitive advantage over others as they will be able to fully realize the benefits of technological innovations to save on energy costs (Moghayedi et al., 2022). In today's world, the importance of a solid warehouse facility has intensified due to the increase in the use of e-commerce (Brown, 2020). This was further intensified with the start of the pandemic as consumers were forced to shop online, making warehouse facilities essential to keep up with rising demands. (Brown, 2020). Warehouses are also important to ensure timely delivery to customers (Pedraza, 2021). Warehousing facilities allow businesses to secure their stock, which means their products will be readily available for shipping whenever an order is placed. This eliminates any time wastage and, if managed correctly, will create an opportunity for the business to gain a competitive advantage over its competition (Tien et al., 2019). The population is also increasing rapidly in South Africa, which will ultimately cause an increase in demand for goods and services. Thus, warehouses will become more critical to this rise in demand (Pedraza, 2021). A warehouse can serve as a central location for receiving, storing, distributing, and shipping products from one location, saving transportation costs. In addition, price stabilization is achieved using warehouses which is one of the key reasons warehouses are so important (Tien et al., 2019). The other key reason warehouses are considered important is that they provide a safe location to store perishable goods. A warehouse is where refrigerators and freezers can be installed to store goods at optimal temperatures. This is important for goods such as food and medication as both require cold storage to prevent spoilage and changes in color and texture (Tien et al., 2019). Although warehouses are considered essential and can provide many advantages to those who use them, their performance must be analyzed to understand how the industry has performed over the past few years. According to Brown (2020), the pandemic has rapidly improved the growth potential of South Africa's logistics real estate sector, including the warehousing demand. Furthermore, the recent shift to e-commerce driven by the nationwide lockdown has allowed both existing retailers and smaller e-commerce role players to gear up the scale of operations that have previously not existed in this sector. Furthermore, with the coming of age of e-commerce in South Africa, there is now a focus on supply chains; the pandemic has intensified this, as there is a great demand to have enough space to ensure firms have enough stock on hand to meet sale demands. According to Fortress (2020), there have been a few proposals for new logistics assets requested by retailers looking to enhance their supply chain and who are looking to grow online offerings. Recently, South African investments into the warehousing and industrial sector provide yields of around 9%, often higher than those generated in regions such as Europe, the United States and Asia.

There is a growing consensus among organizations committed to environmental performance targets that appropriate strategies and actions are needed to make all building activities more sustainable (Moghayedi et al., 2021). If done properly, the building industry has a high potential to make a valuable contribution to sustainable development. This would mean that a building must meet several specific objectives, such as energy efficiency. By 2056, global economic activity will have increased by 500%, global production levels will increase by over 50%, and global energy consumption will have increased by 300%. Sustainable warehousing that uses innovative technology to reduce energy consumption has become essential due to the rise of green warehousing and the increase in research on reducing the carbon footprint of supply chains (Lewczuk et al., 2021). Approximately 10% of worldwide CO2 emissions come from logistical supply chains, and around 11% of the total global greenhouse gas emissions generated by the logistics sector are caused by warehousing activities (Carli et al., 2020). Furthermore, the high demand for energy required for

heating, cooling, lighting, and material handling equipment in warehouses represents around 20% of overall logistical costs (Carli et al., 2020). Therefore, research into the level of energy consumption of warehouse installations has become increasingly important as it has been considered a good marketing factor as it sends a message to consumers that the business is environmentally friendly; this has been done to create a competitive advantage over other warehouses (Lewczuk et al., 2021). Therefore, the energy consumption of a warehouse is no longer only a cost driver but also something that can be used to market a warehouse and increase its financial performance of a warehouse. However, reducing energy usage in warehouses is important to save money or on marketing actions. It is also a result of legal regulations within South Africa due to the energy crisis.

Eskom Holding SOC LTD is a vertically integrated monopoly that supplies 95% of the electricity consumed in South Africa and 38% across Africa (Akinbami et al., 2021). South Africa is among the highest emitters of CO2, currently ranked twelfth in terms of top emitters per capita, as 75% of its energy supply is from fossil fuels (Höhne et al., 2020). South Africa's solar resource is the third largest globally, and it needs to take advantage of it. In addition to producing unsustainable energy, Eskom is forced to conduct rolling load-shedding to avoid total blackout (Jaglin & Dubresson, 2016). As a result, Eskom has been under severe pressure during peak demand periods and operating the grid in crisis mode (Jaglin & Dubresson, 2016). Furthermore, Eskom's incapacity to meet the country's power requirements, resulting in load-shedding, could force energy users to reduce their energy consumption. From 2021 Eskom has been granted permission to increase average electricity prices to 128,24 c/kWh, which will result in a total annual increase of 15%. However, this may increase by 10% in 2022 (Labuschagne, 2021). In the last three years alone, Eskom has increased the average electricity prices by nearly 25% (Labuschagne, 2021). When South Africa became a democracy, Eskom's average electricity prices were among the lowest. In contrast, between 1994 and 1999, price increases never exceeded the inflation rate, which meant that the actual electricity price was declining (Labuschagne, 2021). However, after load-shedding was introduced in 2008, prices skyrocketed.

3. Research Methodology

Since the study of energy efficiency of innovative technologies in South African warehousing facilities is still a less explored area, it requires utilizing qualitative techniques to collect data from the experts to investigate this little-understood phenomenon as proposed by Creswell and Creswell (2017). Therefore, deploying semi-structured interviews in the present study aimed to provide a basis for conceptualizing the key challenges and barriers to adopting innovative technologies in warehousing facilities. Thus, eight warehouse facility managers and technology experts were identified. As a result, interviews reached saturation point after conducting interviews with six interviewees whose profiles are detailed in Table 1. A thematic analysis of the data collected was employed as this is a commonly used inductive approach to analyzing data. Common themes were identified in the interview transcripts using NVivo, and these themes were used for developing the conceptual framework.

Table 1. Interviewees' profiles

Code	Position	Experience	Organization
A	National Technical Manager	22 years	Refrigerated warehousing across SA
B	Property Development	7 years	International distribution, logistics and operates
C	Property development manager	4 years	Logistical warehousing across SA
D	Facility Manager	35 years	logistical warehousing Across SA
E	Technology expert	8 years	Building automation
F	Chief Digital Director	30 years	Operate and manage large warehousing in SA

4. Results

Examining the data extracted from the transcribed interviews, the following constraints and challenges associated with implementing the use of energy-efficient, innovative technologies emerged throughout:

4.1 High Initial Capital Cost of Technology

When a new building idea is put forward, the client is often over-ambitious and will request all the most recent innovative technology included in the building design but doesn't fully understand the costs associated with some of this technology (Participant C). Therefore, from the developer and design teams' side, they cut out the unnecessary technologies requested and the more expensive technology as often they are not tried and trusted in South Africa (Participant C). There are also trends that the project costs are much higher than initially promised because of the introduction of new technology (Participant F). Participant B, it was stated that *"It depends on what technology you*

use. There are still some technologies where it just doesn't make sense financially." Therefore, implying that certain technologies have a reasonable initial cost, but other technologies have initial costs that are not competitive. For example, LEDs are considered expensive, but their costs are starting to decrease as technology improves, resulting in their initial costs becoming reasonable for possible installation (Participant D). However, solar panels and batteries to store solar energy are still extremely expensive.

Participant E had differing views on the initial cost of technology than other participants. Participant E stated, *"The innovative technology is the same thing, just a lot cheaper and more powerful."* Participant E said that the initial cost of technology would decrease soon as the technology evolves rapidly and becomes more stable. Furthermore, as suppliers start to push their technology, savings and the initial cost of such technology will improve significantly. Lastly, as technology is improving rapidly, a challenge for investors is that technology often has a turnaround time of 18 months (Participant E). Therefore, it is crucial to ensure that whatever technology is invested in can either be upgraded or that the supplier where the technology was purchased has a 10-year stock on hand due to the rapid turnaround of technology (Participant E). However, the challenge is that suppliers are reluctant to hold old stock. Therefore, if installed systems break down or malfunction, your only options are to upgrade, as the same technology will no longer be available.

4.2 Prevention of Economic Downtime

Some innovative technologies require an installation time, resulting in an interruption in warehouse operations. Therefore, a significant challenge or barrier to entry is preventing any economic downtime or interruption. According to Participant A, the installation of technology may require alteration of the warehouse to install it, or it may need specific spaces to be empty. Thus, the company will have to forgo any income it would generate from that period. If the storage rooms were full, the installation would not have been approved to prevent any interruption in operation. Therefore, only if the stores are empty would it be considered. Participant A stated, *"They don't want to give that money or spend that money and give up that income if they're getting the benefit of using it later."* The key challenge is a trade-off between investing in the warehouse to ensure future savings and losing out on income generated during installation. Thus, further emphasizing the difficulties of guaranteeing corporate approval plans to introduce innovative technology. Participant B stated that they prevent economic downtime in their warehouses by keeping the existing infrastructure in place but building new infrastructure and cutting over to it once it's completed.

4.3 Approvals from Corporate

Due to the relatively high initial costs associated with implementing innovative technology in warehouses, a major challenge and barrier to its implementation are centered around gaining approvals from corporate. Participant A stated, *"Before I spend any money, I need to get it approved. It's all corporate stuff."* Participant A further commented that if the return on investment is less than three years, it will get approved quicker in budget meetings. Participant E stated, *"The owners are always concerned about budgets."* This emphasizes that corporate structures are hesitant to implement innovative technology if it is outside budgetary requirements. Participant D stated that approvals from corporate would only be granted if the specifications align with Health and Safety standards. The recent fires and looting in South Africa have emphasized ensuring the building is a safe space.

4.4 Inappropriate Design and Operations

When the design team receives the task of developing plans for a proposed warehouse often, there is a lack of thought about how the building design has to suit the building's operations (Participant C). Participant C stated, *"At the end of the day, you try to be very clever, but it's tough to be clever enough to think about all these systems and security in buildings."* Therefore, from a user's experience point of view, often, the technology incorporated doesn't suit their needs for optimal operations (Participant C). Additionally, most architects, as that is where the whole project starts, don't ensure the design of the building suits the operations (Participant F). This was highlighted when Participant F discussed the design challenges, *"We still very much work in a traditional project design environment where its Design and Build so the design side doesn't talk to the build side."* Furthermore, the operations team often adopt more advanced technology than the design technology because they must operate the facility.

4.5 Inability to Retrofit Warehouses for Solar

It must be decided from the initial design stages if the warehouse roof will house solar panels. Most of South Africa's warehouses are not designed to accommodate solar panels as the frame is not strong enough to handle the weight of the cells (Participant C). Therefore, it must be decided beforehand if solar power is required. However, if solar panels are considered for installation after initial completion, many challenges and barriers need to be considered. Firstly, the

surface area and orientation of the roof must be suitable for solar cells as they must face the sun for a maximum amount of time and be large enough to accommodate the solar panel system (Participant C). Furthermore, the installation will require a professional team to work on the roof, bringing many other risks and challenges. Participant D highlighted a key challenge, *"the last thing you want is some pawpaw to climb your roof, bend the sheeting on the roof, which they will do if they walk around on it, and drill holes in your roof to put a solar installation on."* This situation is challenging because the roof structure's integrity is compromised when they drill holes. The warehouse roof structure also needs to accommodate a cleaning team as most solar cells need to be cleaned regularly as the dirtier they get, the less power they provide.

4.6 Lack of Initial Requirements

A key challenge associated with applying for power is that assumptions need to be drawn regarding how much power is required for the building. Build owners or operators will often overstep their power demands, resulting in the company overpaying for their electricity infrastructure upfront (Participant C). This strategy allows for flexibility as building owners would rather pay extra to ensure their power is not interrupted instead of underpaying and not having the proper infrastructure, which may result in blackouts (Participant C). Therefore, when the initial requirements are drawn up, the challenge is to connect the building to the grid and later, energy reduction plans can be thought of and incorporated (Participant C). Timing is crucial as the earlier you make design changes, the cheaper it is at some point, and it becomes unfeasible to make the necessary design changes.

4.7 Technology Not Tried and Tested

South Africa is far behind in technological innovation as most of the technology incorporated into buildings is imported from Germany and China (Participant D). Participants D and F both emphasized the need for data to analyze energy. However, the data is not readily available in South Africa and is challenging to obtain (Participant D). If data is available, its reliability or accuracy may be impaired, bearing in mind that things change year on year, such as the number of rainy or sunny days and the increase in energy charges across the years (Participant C). However, the key challenge is that the data for energy efficiencies does not exist. Participant D, *"I cannot do a proper energy analysis or risk assessment if I do not have the quality data produced."* A key reason behind the lack of data in South African warehouses may be companies focusing on energy efficiency solutions for typical buildings such as hospitality or residentials but are not experts in refrigeration warehouses, for example (Participant A).

4.8 Dealing with Electricity Provider

Electricity provider in South Africa holds a monopoly in energy supply and production in South Africa (Participant D). However, according to Participant B, it is felt that having a secondary source of power is crucial due to the issues that occur when dealing with this monopoly. *"In our country where we've got load shedding and massive outages, just from maintenance, municipal issues, and cable theft, having some secondary power source or ability to save and run the generator. It's crucial."* Participant B stated that running a facility when load shedding is impossible unless the warehouse has a secondary supply of energy, such as batteries or generators.

When applying for energy supply to a building, the process is characterized by many regulations or hoops. Participant C highlighted the challenges faced when dealing with Eskom, *"You need to apply for power to a building from Eskom, which is a very confusing process that takes much time and it's tough to do because they're a very inefficient entity."* Eskom is stuck in the traditional ways of operating and supplying energy (Participant C). Therefore, if anyone suggests anything inventive or outside the typical operating methods, Eskom will shut down the idea as they are stuck in the old, traditional operating methods (Participant C). This challenge is highlighted as Participant C stated, *"You don't want to do anything out of the box because they will sit 30 people in the room with you, and if you've done anything out of line, they can't handle that. They can't handle anything."* This is a critical problem as it cycles innovation (Participant C).

Eskom's tariff structure is based on time of use. Therefore, when electricity is in high demand in the mornings and evenings, the grid will spike (Participant A). Eskom then charges companies, including warehouses, extra during those periods to force the building to switch off or limit energy consumption so that they can provide energy to the rest of the country (Participant A). Additionally, Eskom charges a company at its highest peak for the month. If the building hits a peak for longer than 30 minutes in a specific time interval, Eskom will charge a bill for the peak demand and the average usage (Participant E). In the past, a BMS system would be able to connect to such intervals to time their energy consumption better to avoid expensive bills. However, Eskom no longer allows BMS to connect to this interval, leaving the system operators to determine when such intervals are manual. This was seen as problematic when Participant E implemented such systems into warehouse space. Additionally, this peak system allows Eskom to charge a building with two bills making it extremely expensive. Furthermore, city councils also charge 30% premiums on

power (Participant D). This works because Eskom will manufacture and put energy into the grid, and the council will get their power from Eskom and supply it to the end user. However, the council places a 30% premium when they charge the user for power if they are using power provided by the city council (Participant D).

4.9 Restrictive Legislation

Participant B highlighted a key challenge when dealing with the current restrictive legislation, *"To date, we've had to limit all of our developments to one megawatt."* However, Participant B remained positive as there are plans for the legislation to change to allow a building's producing capacity to increase, which will enable installations to be sized correctly for energy.

Participants B, C and D mentioned restrictive regulatory conditions surrounding solar energy production. Participant B stated that *"the only disadvantage we've had are regulatory. You have to jump through many hoops to get something like solar specifically."* Participant D expanded on this as it was mentioned that during peak times, solar panels could produce more energy than the building can use, which can be recycled into the system. However, the challenge is that there are regulations that state individuals are not allowed to put power into the grid and charge on it. Potential secondary producers of power and city councils are all waiting for the government to enact legislation that will allow people to manufacture their power. Still, the legislation is not yet complete (Participant D). Due to the regulatory barriers that Eskom has in place, warehouses that can house solar panels to substitute a portion of their power cannot provide power to the grid and earn income on it (Participant D). According to Participant D, the law states that if a building is generating power through solar panels and the area has load shedding, the solar panels must be turned off; thus, when the council or Eskom cuts the power supply, the secondary source of power also must be turned off. The government has also been slow with the digital revolution (Participant E). For example, data providers in South Africa are requesting an extra IoT band where all devices with intelligence can join the additional band and transmit data. Participant E said this operation should have been launched four years ago but has not been launched because of the government's restricted legislation.

4.10 Additional Regulations

"Warehouses have to abide by regulations that ensure a certain fresh air flows through the space. Therefore, you cannot completely close the fresh air supply and only use the HVAC system" (Participant E). Presence detectors monitor this, and if there is no presence detected in 45 minutes, the system is turned off (Participant E). Certain warehouses also have strict temperature requirements, such as pharmaceutical warehouses (Participant E). Therefore, there are regulations requiring the HVAC system to ensure temperatures always remain between 22 and 24 degrees Celsius and ensure humidity levels between 40% to 60%. Regulations make energy saving in these warehouses difficult Participant E stated, *"Saving energy in a pharmaceutical warehouse is very difficult because of stringent conditions."* However, these regulations and environmental conditions are in place to minimize the risk of drugs becoming destroyed (Participant E).

"The internal racking and lighting of the warehouse influence each other's performance" (Participant D). Participant D explains the following regulations regarding lighting and stacking requirements; however, these regulations also contribute to improved performance. The best warehouse in the logistics industry will be between 12 and 15 meters in height to the underside of the eaves. The gap between the Aisles can also have a major influence on the level of lighting (Participant D). The height of the racking and the distance between aisles need to ensure 400 lux lighting in the warehouse to comply with the lighting regulations, which is also the optimal level of lighting for a warehouse (Participant D).

5. Discussion

It is evident that adoption levels of innovative technology in South African warehouses are low, with less than half of the participants adopting all available technology. This follows Moghayedi et al. (2022) view of slow widespread adoption levels throughout developing countries such as South Africa. From the findings, it was clear that implementing the technology was to reduce energy consumption; however, following Lewczuk et al. (2021), an apparent reason for this implementation was to ensure competitive advantage and improve marketability and property values. The issues and difficult climate around electricity providers in South Africa were included in the literature review, which surfaced in the findings section. According to Jaglin & Dubresson (2016), the main electricity provider in South Africa is a vertically integrated monopoly that supplies 95% of South Africa's electricity. Still, in recent times the entity has faced many challenges. The findings confirmed this as it was stated that the electricity provider held a monopoly on energy supply and production. The challenges faced by South African electricity provider was also highlighted in the findings, as it was stated that it is crucial to have some secondary source of power in South

Africa due to the challenges associated with load shedding, municipal issues, cable theft and poor maintenance services. The findings confirmed that electricity providers in South Africa are inefficient entities, and dealing with them is a challenge. However, there are plans to become less reliant on a grid using renewable energy.

The South African government wants to adopt a more renewable energy supply by 2030. The aim was to generate 42% of its electricity from renewable sources (Craig et al., 2017). This goal surfaced once the findings were investigated, as it was stated that the city councils and potential secondary producers of power are waiting for the government to enact legislation allowing people to produce their power, thus confirming that there are plans to move to a renewable energy supply plan. A key method to produce renewable energy in South Africa is solar panels. However, challenges and implementation considerations must be fully understood before installing solar panels. The findings stated that certain warehouses could not house solar panels as from the initial design stages, it has to be decided if warehouses will be installed. Hence, the roof can hold them. Furthermore, the surface area and the orientation of the roof must be suitable for solar panels, which confirms Boztepe & ÇEtİN (2020) statement that only some warehouses can house solar panels.

Implementing innovative technology will challenge its entry into the property market (Green et al., 2022). According to Dadzie et al. (2018), the cost of technology is a major barrier for investors, confirmed in the findings as the interviewees mentioned that the high cost of implementing innovative technology is often the reason corporates reject the idea. Additionally, the results confirmed that some technologies did not make sense financially to incorporate into warehouses. Jobber et al. (2019) mentioned that property professionals are unaware of its benefits due to the poor salesmanship of companies selling such innovative technologies. This is confirmed in the findings as the interviewees mentioned that data about the benefits of such technology is not readily available in South Africa, thus deterring them from using it in their warehouses. Moghayedi et al. (2022) stated that a barrier to entry is that technology often needs to be replaced, which may lead to the replacement of the entire unit. The findings mentioned that a key disadvantage was that technology installed in a warehouse is susceptible to upgrades if a sensor or two fails, which may lead to the entire system failing, thus requiring an upgrade. These replacement costs are a significant barrier to entry as over and above the initial cost of innovative technology are the replacement costs that may arise.

Lastly, the findings confirmed that only a few companies in South Africa were doing proofs-to-concept of developing strategies to incorporate technology. The participants confirmed that a lack of awareness and data is another barrier to adopting innovative technologies in the warehousing industry in South Africa. Furthermore, the technology is too expensive and not being tried and trusted.

6. Conclusion

Even though the study proved the potential of innovative technologies in improving warehouse facilities' energy efficiency, various challenges and barriers must be overcome before such technology is installed in warehouse facilities in South Africa. It can also be inferred from the study findings that the major challenges and barriers include approvals from corporate, as due to the high initial cost of implementing innovative technology, corporates are hesitant to invest in it. Additionally, the economic downtime which may arise during installation was a major barrier to entry. Other challenges and obstacles that were identified relate to the design and building. Often, the users of a warehouse face issue that arise after implementing innovative technology as the design side does not work with the build side. Lastly, various challenges and barriers are associated with the current energy supply in South Africa as the electricity provider holds a monopoly in energy supply but is an incredibly inefficient entity facing many issues, such as their inability to supply stable energy to the country. A key solution to this would be to allow for secondary power producers. Still, there is restrictive legislation surrounding renewable energy production, thus making it illegal to produce and sell your power. The hoops people need to jump through to implement innovative technology to produce their power supply is one of the major challenges and barriers preventing the adoption of innovative technology in South African warehouses. To enhance the adoption of innovative technologies in warehouse facilities in South Africa and therefore improve the energy efficiency in these facilities, there should be more guidance and incentives from relevant authorities in South Africa.

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