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Factors Influencing the Adoption of Photovoltaic Panels as a Method of Sustainable Construction Material: A Case of Zambia

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Abstract

Recent years have seen the increase in the shortages of electricity energy. Roof material, photovoltaic roof panels are among the emerging roofing techniques that are being adopted particularly in developed countries like China, America and Jordan. Despite the remarkable research about the benefits of photovoltaic roof panels, the adoption of this technology is still low and the literature that discusses the factors influencing their adoption is limited. It was on this background that this research investigated the factors that influence the adoption ot photovoltaic roof panels as an alternative for reducing the consumption of electricity energy and address the electricity energy shortages. Qualitative data were collected from ten contractors drawn from a single case country of Zambia. The findings of this research identified both the internal and externa factors that influence the adoption of photovoltaic roof panels as a solution for the widespread electricity energy shortages. These factors included policy, economics, social, technology, awareness, attitude, availability, affordability, accessibility and self-efficacy. The findings inform policy makers on how to formulate policies that favour the implementation of photovoltaic roof panels. Furthermore, the findings of this research impact on the environment by suggesting photovoltaic roof panels as an alternative for zero-energy buildings as well as promoting an environment with reduced carbon.

Keywords
Photovoltaic, Adoption, Sustainability, Construction.

1. Introduction
Literature provides evidence of an energy crisis the world over (Ibrahim et al., 2026) and roofing material play an essential role in energy efficiency as solar radiation absorbs significant amount of heat in hot weather and loses a significant amount as well in cold weather. Based on the review (Abuseif & Gou, 2018). The roofing techniques common on the market include concrete roof, cool roof, insulated roof, roof garden, bio solar, double skin roof, roof ponds, skylight roof, wind catcher and photovoltaic panels. The focus of this study is on the photovoltaic panels, demonstrated in Figure 1.

Figure 1. Photovoltaic Roofing tiles

Photovoltaic panels, is a technique for capturing solar radiation to produce electricity, and is considered one of the most promising markets in the portfolio of renewable energies, due to its potential to mitigate global warming (Weckend et al., 2016). Literature has evidence that PV is an economically viable alternative to electricity energy (Siu-Kit Lau 1, 2021). For example, the deployment of PV roof panels saves costs since their installation aim is to achieve a zero-energy building (Shahee et al., 2024.). Furthermore, PV roof panels are a solution for addressing the high demand for energy globally (Ibrahim et al., 2026), hence the exponential growth of PV roof panel deployments as is evident in Figure 2, This notion is supported by literature that asserts that "solar photovoltaics, as one of the important renewable energy sources" (Li et al., 2024, p. 1)

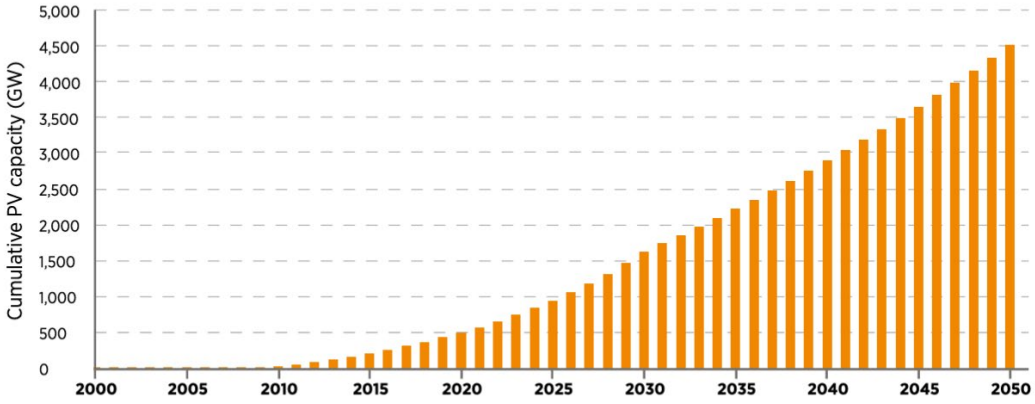

Figure 2. Projected cumulative global PV capacity (Source: Weckend et al., (2016))

Figure 2 depicts that the projected cumulative PV capacity will reach 4,512 Gigawatts (GW) in 2050 from 222 GW in 2015 (Weckend et al., 2016). Despite the high rate of growth in the deployment of PV, such is not a global growth as it is limited to developed countries in Europe, America and Asia, while there is limited installations of PV in developing countries, Africa in particular (Weckend et al., 2016). Furthermore, research exits that suggest ways for using building roofs to improve thermal comfort, improve energy performance, reduce negative impact on the environment while promoting social and economic solutions (Abuseif & Gou, 2018). "In recent years, research on the intention to adopt solar photovoltaic technology has yielded rich results. However, controversy still exists regarding the key antecedents of households' intention to adopt solar photovoltaic technologies" (Li et al., 2024, p. 1). Contrary

to the advancement in research and the remarkable growth on PV panel deployment, there is limited literature that discusses the factors influencing their adoption, barriers to their usage and their impact on the economy (Moghayedi et al., 2023) argues that . Confirming this observation, literature shows that despite the significant benefits of installing PV roof panels, the adoption rate of this technology remains low (W. Li et al., 2024)More so discussions based on the context of Africa, with a particular focus on Zambia are very scarce.

2. Literature Review

Several researchers have focussed conducted studies on adoption factors and have identified many factors. For instance, Forrousso et al. (2024) used the case of Morocco to describe how can result in residential buildings with a net zero energy. Similarly, Moghayedi et al. (2023) used the case of Cape Town in South Africa to examine the impact of green methods and technologies on the environmental sustainability of supportive education buildings and emphasized that the implementation of green methods and technologies improves resource efficiency, circular economy practices and progress and achieves a net-zero carbon targets for supportive education buildings and the university as a whole. Another study by Ibrahim et al., (2026) evaluated the floating photovoltaic systems' performance and technologies associated with it. Their findings reveal that this technology is an optimal solution for meeting the ever rising global demand for energy and it also minimizes the ecological impacts. Research has also been conducted, which considers the management of waste from the solar photovoltaic panels and confirm the need for stakeholders to implement plans for decommissioning the waste from solar photovoltaic panels for the benefit of the environment (Weckend et al., 2016). Policy, economics, social and technological factors were identified as the major factors that impact the adoption of photovoltaic rural households in China (Li & Dai, 2024). A similar study analysed the determinants of the intention to adopt the solar photovoltaic among the households in China and confirmed the role played by attitude and government incentives influence the adoption of such technologies (Li et al., 2024). On a different note, Abu Qadourah and Alnusairat, (2024), evaluated the aesthetic perception of photovoltaic installation on the apartment building façade in Jordan and reveal that all aesthetic dimensions affect PV installation. Recently, Shahee et al. (2024) explains how to reduce the energy consumption of buildings by implementing insulation scenarios and using renewable energies.

3. Methodology

A purposive sample of ten construction companies enable the collection of qualitative data in accordance with Bowen (2005) who emphasises an in-depth investigation of the phenomenon of interest, uses purposive sampling as opposed to random sampling. The purposively identified ten research participants from construction companies operating in Lusaka, Zambia. This collection of qualitative data from these research participants afforded the researcher to fill the gap in existing literature, which shows that while the use of qualitative methods is a well-established approach , van Dijk (2006) argues that qualitative methods are rarely used in research. Adding to this fact is that data collected through qualitative methods is valuable for the sense-making about phenomena that it affords (Bowen, 2005).

To achieve the research purpose, the ten construction companies participating in this research were drawn from a single case country of Zambia. This choice was informed by the convenience and proximity to the researchers who are based in Lusaka, Zambia. Using a single case country enabled the researchers to make an empirical inquiry into a complex phenomenon of solving the energy challenges within its real-life context (Lee & Baskerville 2003). Additionally, Zambia is engaged in massive construction projects and yet her economic development is affected by the negative impacts of energy shortages, which sometimes last 21 hours of black out (Short, 2024); Literature shows that the power shortages and load shedding currently experienced in Zambia have negative implications on the economic growth and quality of life of people living in Zambia (Sikananu, 2024), More so, literature confirms that the prolonged power outages have compromised the quality of service delivered by such major companies as MTN, Zamtel, and Airtel (RANJAN, 2024)

Pseudo names like [Con001] were assigned to the ten research participants for ethics reasons and ensuing the anonymity of the research participants. Data were collected over a period of a single calendar month and the collection of data was conducted through semi-structured interviews. The appropriateness of this data collection instrument was informed by Richardson (2011) who argues that without the voice of the end user, we fail to understand the unique needs of the person as well as the community. The Researcher worked with the small sample size of ten corruptors while aware of potential criticism relating to generalisability issues. The researcher's choice was however informed by Lee and Baskerville (2003), who argued that although an increase in the sample size may sometimes lead to an increase in reliability and/or validity, it does not imply greater generalisability. The decision to use a relatively small

sample was also based on the need for easy management, access and willingness to participate. In interpretive research, numbers are not as important as the quality of the collected data Shetty (2022), Despite the small sample, a fair representation of the contractors was achieved.

4. Findings

Results from the research participants show a lack of awareness of the potential of PV as a technique for addressing the wide-spread energy problems. An analysis of the results on NVIVO lead to two broad categories of themes of factors that influence the adoption of PV roof panels. These emergent themes relate to the internal and external factors.

4.1 External Factors

The external factors concerned the policy, economic, social and technological factors. show that the adoption of PV as an energy saver. These four external factors are discussed first.

Policy: Several issues were raised by the research participants regarding policy as an external factor that influences the adoption of PV roof panels by constructors. For example, **[Con001]** was concerned about a lack of policies for governing the implementation of PV roofing panels. This view was supported by **[Con009]** who showed that the policy frameworks have not been devised that support the full scale usage of PV roofing panels as a means for dealing with the recurrent problem of electricity power outages.

Economy: The economy was an integral factor since the research participants argued that they could not implement PV roof panels because many of the intended consumers are not financially stable to invest in this roofing technique. An important assertion was made by **[Con003]** who indicated that their business niche is the high density residential owned by low-income members of society, which makes it very difficult for them to prioritize PV roofing over basic bread and butter issues.

Social: The findings also show the social effect of adopting PV roof panel proved true in that the participants were either motivated or demotivated by the society. For example, some participants felt that in their community there are no implementations of PV roof panels which is why they did not emphasize their deployment.

Technology: The findings also link the adoption of PV roof panels to the nature and characteristics of this technology. For instance, **[Con003]** alluded that if the PV roof panels are easy to install, then it becomes easy to convince their clients to choose PV roof panels over other roofing technologies. In a similar note, **[Con007]** and **[Con010]** agreed that if the installation of a technology is simple, then customers do not hesitate to invest in it while shunning away from technologies that are difficult to install.

4.2 Internal Factors

In addition to external factors emerged themes relating to internal factors which proved to play a major role in the adoption of PV roof panels. These internal factors included: *Awareness*: The findings of this research show that awareness of the technology such as the PV roof panels plays an important role in the adoption of PV roof panels. While the research participants were aware of PV roof panels, they indicated that the majority of their customers were not aware of this technology which made movement of this technology become worryingly slow, which means there is need for awareness campaigns for them to succeed [Con010] and [Con008]. Awareness also links with attitude.

Attitude: The current trend is placing more importance on the electricity energy than on any other source of energy. For example, [Con004] felt that it was a waste of resources to invest in PV roof panels since there is a supply of electricity. These sentiments were also echoed by [Con009] and [Con005] the electricity outages are not permanent as they get restored after some time therefore there is no urgent need to invest in additional energy to solve a temporal problem. On the other hand, were other participants who value the continuity of energy supply. For example, [Con007] was of the opinion that no time of the day or night must be without electricity for fear of crime, as such he found it imperative to make an effort to invest in supplementary energy supplies. [Con002] and {Con006] echoed similar sentiments. Another factor of interest was the simplicity of installing the PV roof panels because the more complex it is the less attractive it becomes to the roof installers. [Con0010], [Con006[.

Self-efficacy: This factor emerged from discussions regarding the sustainability of the technology. For example, [Con004] was worried that in the event they install the PV roof panels, Will the customer circumstances allow for a

continued maintenance of such a technology? This notion was confirmed by research participant [on005] who argued that if the customers do not believe in a technology, then its adoption can never succeed. Similarly, [Con006] and [Con008] concurred that it is important for people to believe in their strength to accomplish a task otherwise the success of a technology in question will be negatively affected.

Availability: The results also show the importance of availability of technology in its adoption. The research participants argued that they can only adopt a technology that is readily available in the market [Con002], [Con003], [Con009]. It was clear that the adoption of PV roof panels was negatively impacted by the limited supply of such technology as was expressed by [Con007]. Linked to availability was accessibility.

Accessibility: The research participants suggested that for the PV roof panels to widely adopted, there was an urgent need to ensure they are accessible [Con004], [Con009]. Regarding these two factors, [Con001], [Con010] and [Con006] unanimously agreed that availability and accessibility are not enough if not coupled with affordability.

Affordability: The cost of the technology determines if it will be adopted or not. Usually the cost is linked with the value gained from that technology. Regarding the PV roof panels, the research participants indicated that while there is value in adopting PV roof panels, the exorbitant costs are hindering their adoption [Con001].

5. Discussion

These are not unique findings since literature has discussed similar factors concerning technology. For example policy, economic and social had a stronger influence on the adoption of PV panels for buildings in rural homes China while technological factors had a weaker influence (Li & Dai, 2024). On the contrary, findings relating to the installation of PV roof panels in apartments in Jordan found technology simplicity to have a stronger effect in the adoption of the PV roof technology (Abu Qadourah & Alnusairat, 2024). Awareness was not unique to this study since it was also identified in a study relating to PV roof implementation in China (Li & Dai, 2024). Affordability of technology has also been identified in literature as a factor that influences technology adoption. For example, this factor is discussed in a study setting of Florida relating to the implementation of PV roof panels (Shahee et al., 2024). The major impact of attitude on the adoption of technology has been discussed in literature. For example, Davis (1985) found that attitude influences technology acceptance. Similarly, recent studies still. the major role played by attitude in the adoption of such technologies as PV roof panels (L. Li & Dai, 2024). Availability is also a common factor that has been discussed in literature in relation to technology adoption (Riddlesden & Singleton, 2014; Hsieh et al., 2008; Mutunhu et al., 2022). Literature also links accessibility to technology adoption. For example, Patricia Aguilera-Hermida, (2020), confirm this by showing that college students' acceptance of online learning during COVID 19 was determined by the accessibility to the online platforms. Similarly, Self-efficacy has been emerging in adoption discussions (Aguilera-Hermida et al., 2021).

6. Conclusion

This research sought to establish the factors that influence the deployment of PV roof panels as means for addressing the shortages of electricity energy. The analysis of the collected qualitative data identified both the internal and external factors influencing the adoption of PV roof panels by contractors. The internal factors included awareness, attitude, resistance to change, income, relative advantage were among the chief factors influencing the implementation of PV roof panels by contractors. In addition, were the external factors which included policy, economic, social and technological factors. These findings impact both the policy makers on formulating policy frameworks that support PV roof panel deployment, government by recommending PV roof panels as a solution for addressing the electricity energy shortages, environmentalists on devising methods of decommissioning the PV roof panel that have exceeded their life span r as well as recommending the installation of PV roof panels which have a potential to pollution (Li et al., 2024).

This research has several implications as it makes contributes to practice by informing policy makers on the challenges of implementing PV panels so that these challenges could be addressed (Weckend et al., 2016). The deep insight into the factors influencing the implementation of PV is vital to key stakeholders such as policy makers who are responsible for developing flexible regulatory frameworks particularly for PV waste management. The complexity or simplicity of installing a technology plays an important role in the decision to invest in that technology (Abu Qadourah & Alnusairat, 2024).

The research has an impact on the contractors on how to encourage and consumers to consider PV roof panels as a valuable alternative to traditional roofing methods.

7. Limitations and Recommendations for Further work

This research was limited by a small sample of ten contractors. A larger sample could result the collection of more insightful data. Another limitation relates to the single case country, engaging with multiple country cases could lead to in-depth knowledge of the factors influencing the implementation of PV roof panels. The last limitation relates to the qualitative data which is limited I subjective stories, narrations and experiences, which might not have been proven to be true and rather based on intuition. Mixed data including quantitative data could have been useful for expanding the knowledge of factors that influence the deployment of PV roof panels as a means for dealing with electricity energy shortages.

References

Abu Qadourah, J., & Alnusairat, S. Integrating aesthetics and sustainability: evaluating the aesthetic perception of photovoltaic installation on the apartment building façade in Jordan. *Archnet-IJAR*, 2024, https://doi.org/10.1108/ARCH-02-2024-0038

Aguilera-Hermida, A. P., Quiroga-Garza, A., Gómez-Mendoza, S., Del Río Villanueva, C. A., Avolio Alecchi, B., & Avci, D. Comparison of students' use and acceptance of emergency online learning due to COVID-19 in the USA, Mexico, Peru, and Turkey. *Education and Information Technologies*, 26(6), 6823–6845, 2021, https://doi.org/10.1007/s10639-021-10473-8

Bowen, G. A. Preparing a qualitative research-based dissertation: Lessons learned. *The Qualitative Report*, 10(2), 208–222, 2005.

Davis, F. D. J. A technology acceptance model for empirically testing new end-user information systems: theory and results. Massachusetts Institute of Technology, 1985.

Forrousso, S., Idrissi, S., Mana, A., Wakil, M., Jamil, A., Brigui, J., & Azzouzi, H. Optimal sizing of off-grid microgrid building-integrated-photovoltaic system with battery for a net zero energy residential building in different climates of Morocco. *Results in Engineering*, 22(May), 102288, 2024, https://doi.org/10.1016/j.rineng.2024.102288

Hsieh, J. J. P.-A., Rai, A., & Keil, M. Understanding digital inequality: Comparing continued use of behavioral models of the socio-economically advantaged and disadvantaged. *MIS Quarterly*, 32(1), 97–126, 2008, https://doi.org/Article

Ibrahim, S. A., Yusop, S. M., Daud, M. Z., & Suyono, H. Evaluating the horizon of renewable power: A comprehensive review of floating photovoltaic systems; performance and technologies. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 63(2), 67–88, 2026.

Lee, A. S., & Baskerville, R. L. Generalizing generalizability in information systems research. *Information Systems Research*, 14(3), 221–243, 2003.

Li, L., & Dai, C. Internal and external factors influencing rural households' investment intentions in building photovoltaic. *Energies*, 17, 1–20, 2024.

Li, W., Zhu, J., Li, Y., Li, Y., & Ding, Z. Determinants of solar photovoltaic adoption intention among households: A meta-analysis. *Sustainability*, 1–18, 2024, https://doi.org/10.3390/su16188204

Moghayedi, A., Michell, K., Hübner, D., Jeune, K. Le, & Massyn, M. Examine the impact of green methods and technologies on the environmental sustainability of supportive education buildings: perspectives of circular economy and net-zero carbon operation, 42(3), 201–222, 2023, https://doi.org/10.1108/F-12-2022-0161

Mutunhu, B., Dube, S., Dube, S. P., & Mpofu, S. A framework for transitioning to virtual classes during life-threatening pandemics like COVID-19. *European Conference on E-Learning*, 21(1), 279–287, 2022, https://doi.org/10.34190/ecel.21.1.900

Aguilera-Hermida, A. College students' use and acceptance of emergency online learning due to COVID-19. *International Journal of Educational Research Open*, 1, 100011, 2020, https://doi.org/10.1016/j.ijedro.2020.100011

Richardson, J. W. Challenges of adopting the use of technology in less developed countries: The case of Cambodia. *Comparative Education Review*, 55(1), 8–29, 2011.

Riddlesden, D., & Singleton, A. D. Broadband speed equity: A new digital divide? *Applied Geography*, 52, 25–33, 2014, https://doi.org/10.1016/j.apgeog.2014.04.008

Shahee, A., Abdoos, M., Aslani, A., & Zahedi, R. Reducing the energy consumption of buildings by implementing insulation scenarios and using renewable energies. *Energy Informatics*, 7(18), 1–29, 2024, https://doi.org/10.1186/s42162-024-00311-9

van Dijk, J. A. G. Digital divide research, achievements and shortcomings. *Poetics*, 34, 221–235, 2006, https://doi.org/10.1016/j.poetic.2006.05.004

Weckend, S., Wade, A., & Heath, G. ABOUT IEA-PVPS, 2016, www.iea-pvps.org