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Enhancing the Appearance of Building Integrated Photovoltaics (BIPV) Through the Application of Traditional Symbols: A Case Study

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Abstract. Over the past years, advanced renewable technologies such as Building Integrated Photovoltaics (BIPV) has transformed to become more efficient, reliable, less costly and attractive. A migration to Net-Zero Energy Buildings (NZEB) and push for Green Buildings (GB) is a major driver for the adoption of BIPVs, not only in developed countries, but also in the developing world. Fundamental issues such as cost, aesthetics, technological lock-in, awareness, and socio-economic barriers have been identified as major hindrances to the advancement of BIPVs especially in developing countries. Understandably, there have been growing concerns about the aesthetics of BIPVs especially as it directly replaces conventional building materials. It has also been established in several studies that symbolism and cultural acceptance have direct impact on architecture. For instance, in Ghana, symbols like “Adinkra” are valued as epitome of beauty, hence replicated on clothes, buildings façades, emblems etc. A hypothetical question is established here; Will replicating traditional symbols such as “Adinkra” on intended building materials such as BIPV for façade and roofing influence its adoption in Ghana and alike countries? This paper establishes and analyze the nexus between traditional design symbols and buildings with the aim of developing a viable design prototype for BIPV developers and installers by drawing from existing literature and design expertise. Here, traditional Ghanaian Adinkra symbols have been used as case study for BIPV application in futuristic buildings. A pilot illustration of a BIPV building with Ghanaian Adinkra symbols have been demonstrated using graphic design software. Traditional Adinkra symbols will have direct bearing on the acceptance and adoption of BIPVs in Ghana, considering the value and cultural attachment Ghanaians have with these symbols. This paper will serve as a resource material for BIPV developers and installers.

INTRODUCTION AND BACKGROUND

Gradually, the world is getting more conscious about the ramifications of climate change due to visible signs [1], [2], hence a sustainable approach towards reducing Green House Gas (GHG) emissions is imminent. On the other hand, many countries, especially in the developing world are faced with various degrees of electricity crises, which impedes economic growth and development [3]–[5]. Renewable Energy Technologies (RETs) such as solar has proven to be a capable and reliable source of electricity to replace cruddy energy sources such as fossils [6]. Advancement in solar technology has led to the exploration of sophisticated forms of application such as Building Integrated Photovoltaics (BIPV). BIPV simply means the use of solar PVs to replace conventional building materials such as roof, windows and façade such that they form part of the building envelope. Here, the cost of the original building material is completely off-setted, and the general appearance of the building is enhanced (aesthetics) making BIPV advantageous over others [7]. BIPVs have great prospects in contemporary solar PV application in buildings especially

as the push for Net Zero Energy Buildings (NZEB) and Green Building Technologies (GBTs) advances globally. General concerns about the aesthetics of solar PV applications on environmental landscapes and especially on modern architecture has been one of the major drivers of BIPV [8]. The idea that PVs can harmoniously blend into the building envelope without sticking out, or becoming an ad-on comes off as a welcoming news for homeowners and architects.

Although BIPVs have been touted as the future of solar PV application in buildings, its adoption has been relatively slower than expected. Fundamental limitations such as; technical barriers, the issue of efficiency, design and aesthetics, public perception, awareness and education, economic limitations and limited demo projects [9]–[13] have been identified as key limitations to its adoption. It is therefore imperative that keen attention is paid to the market and consumer taste when it comes to the adoption of BIPV especially as it replaces building materials. Several studies have shown a positive relationship between consumers and symbolism especially when it comes to architecture [14]–[16]. This demonstrates that there is a clear-cut nexus between traditional symbols and architecture, which cannot be underestimated despite modernity. In many countries, popular traditional, cultural or religious symbols have been engraved or printed onto monumental, religious, private and public buildings. These symbols are generally upheld, respected and acknowledged by many people. Some theorist opine that culture and tradition has been classified as one of the major pillars of sustainable development [17].

Understandably, BIPVs for obvious energy producing abilities cannot be treated as an ‘ordinary’ building material, however an enhancement in its appearance through the use of traditional symbols may encourage potential adopters. A hypothetical question is drawn here: Will the incorporation of traditional symbols influence the adoption rate of BIPVs among homeowners and stake holders?

This paper therefore discusses Ghana’s energy issues and the relevance of BIPV adoption. It employs illustrations of traditional Ghanaian Adinkra symbols on BIPV materials as epitome of architectural beauty. Futuristic drawings of BIPV buildings with traditional Adinkra symbols embedded in them have been shown. This paper also synthesises literature from previous studies on Ghana’s energy sector, solar energy, BIPV technology, traditional Adinkra symbols and relies heavily on a design approach. Although this study does not demonstrate a market survey for BIPV adoption in Ghana should Adinkra symbols be applied, the authors strongly believe that its adoption by BIPV manufactures can potentially affects the rate of adoption in Ghana and alike countries. The next sub-section discusses Ghana’s energy problem, solar and BIPV prospects.

Meaning, Overview and Brief History of Building Integrated Photovoltaics (BIPV)

Once upon a time, solar energy for homes could only be identified with “sprouted” panels on rooftops and compounds in rigid plastic frames. These days, thanks to advancement in technology and modernity, solar energy has emerged into a more sophisticated and architecturally salient mode of application. Building Integrated Photovoltaics, BIPV for short basically refers to the use of photovoltaic materials to replace conventional building materials such that they form part of the building envelope [18], for instance in figure 2 below. Whether as a primary or auxiliary source of electricity, BIPV has gradually become an integral energy source for buildings. The advantages are numerous, for instance; the offset of cost of original building materials, reservation of land space and aesthetics [19]. The hope for a Net Zero Energy Building as the future of architecture partly rides on BIPV exploration especially in areas of abundant sunlight.

The debate of Building Applied Photovoltaics (BAPV) against its counterpart Building Integrated Photovoltaics (BIPV) has lingered on since its inception. The conservatism and track record BAPV have enjoyed naturally gives it a lead over the “new entrant” BIPV in the built and construction industry. Social acceptance, technological limitation and cost have been cardinal limitations to the wide spread of BIPVs in the past [20]. However, in recent times the dynamics are changing, as BIPVs are making a headway in the architectural world. The emergence of BIPVs in the early 1970’s introduced the use of basic aluminum framed solar panels to be integrated into parts of building skins especially in remote off-grid areas. Fast track to the 1990’s, BIPV blew up for commercial scale and has since been championed by various stake holders [21].

The first largest BIPV production installation emerged in Germany by Pilkington in 1993. Gradually, BIPV continued to receive a lot of attention and became an attractive monuments for the early adopters [22]. The solar idea thrived “beyond the roof” and gradually found its way into the skin of various buildings, either forming the façade, cladding, windows among others. Roof top mounted applications still dominate in the BIPV world, as about 80% of BIPVs are mounted on the roof and the remainder on façade. This naturally means the market segment for BIPV roof is relatively higher than the others. Although the initial idea of BIPV seemed out of earth and technically challenging, gradually, the technology has improved to cater for its limitations. Now that talks about NET zero energy buildings

has been heightened, the future of BIPV seems more promising. BIPV companies are increasing production capacity whereas designers and engineers also explore various creative means of BIPV application.

These days, BIPV technology has become comparatively cheaper thanks to the advanced technological research and increased production capacities of solar PV. As awareness of climate change and the “desire to go green” increases, photovoltaics have become an easy option to consider due to its modest nature [23]. These days, manufacturers are keen on meeting the taste of the market, therefore there have been a significant improvement when it comes to appearance, cell technology, color and make of PVs for BIPV purposes [24].

In BIPV application, PVs ought to appear in different materials and not the regular rigid plastic-framed shapes. Advancement in BIPVs has therefore brought about different materials and products that can easily mimic and replace conventional building materials. The appearance of BIPV is as essential as its efficiency. Modern buildings have growing taste and concerns about aesthetics, hence the exploration of varied shapes, colors, textures and prints to ensure it fully matches the aesthetical values of original building materials is essential. The next section shall explore the prospects of Ghanaian traditional Adinkra symbols as a potential driver for BIPV adoption in Ghana and alike countries.

THE RELEVANCE OF TRADITIONAL “ADINKRA” SYMBOLS IN GHANA

Symbolism forms a significant part of indigenous Ghanaian culture which is used to express the beliefs, values and background of a particular group of people. Usually, there is a clear linkage between specific words, sayings or proverbs and these symbols. This gives meaning and tangibility to traditional symbols although sometimes they can be subjected to personal opinions [25]. In Ghana, Adinkra has emerged as the most popular symbol that is widely used for various purposes. For instance, they are printed on cloths, used as emblems, adopted by various ethnic groups and clans as totems [26], used for industrial and commercial purposes such as company logos and have even featured in intercultural communication games [27].

According to history, Adinkra was named after a famous Ghanaian King (Nana Kofi Adinkra) who became popular in the Asante empire in the 19th century, after the then Asante’s defeated and captured him after a war to their capital, Kumasi. The craftsmen among the captives started using these Adinkra symbols as stamped patterns. Adinkra which literally means “Goodbye” in the famous Ghanaian language (Twi) was later fully adopted and replicated as patterns on textiles by the Asante’s [28]. The complexity of saying goodbye to a loved one spurs mixed feeling, sometimes of pain and happiness. The former is usually associated with death, and considering the dreadful nature of death among humans, the craftsmen demonstrated these emotions through philosophies, messages and abstract symbols. Meanings were given to each of these symbols and replicated through dyes on various substrates including fabric, wood, metal and pottery for both commercial and personal use [29]. Since then, Adinkra has grown to become one of the most popular African symbols which is acknowledged globally [30].

Ghanaians uphold Adinkra with pride and dignity. Presidents, Chiefs and well acknowledged leaders wear popular “Kente cloth”, mostly made with patterns of Adinkra to various ceremonial gatherings. This goes a long way to endorse the high stakes of Adinkra in Ghana. Adinkra has also been adopted for various architectural purposes. Many traditional minded people and millennials with a taste of antiquity have adopted Adinkra symbols for cladding, decorations, facades etc. in buildings. Also, national monumental buildings, churches and other religious temples have been adorned by Adinkra symbols as some proponents believe that there is a relationship between these Adinkra and spirituality [31].

Some Popular Adinkra Symbols in Ghana and their meaning

Various Adinkra symbols have names, meanings and philosophical underpinnings. This paper highlights five popular Adinkra symbols and their meanings [30]:

The Akofena symbol (Sword of war) (see Fig. 1) showcases a crisscrossed sword. In Ghana, the sword signifies heroism, strength, bravery and fearlessness. Many traditional powerful chiefs and leaders have adopted this symbol as a motif due to its significance. Apart from all the aforementioned meanings, the crisscrossed sword signifies the authority of the state. The Akoma (heart) (see Fig. 2) just like in everyday life, the symbol of heart signifies patience, love, tolerance and containment. This symbol is adopted by many Ghanaians especially as a sign of peace and love. The Gye Nyame (Only God) (see Fig. 3) is valued by Ghanaians as portrays their relationship with the supreme being (God), hence give credence to Him in every instance. The ‘Gye Nyame’ symbolises the sovereignty and preeminence of God. Many Ghanaians adore this symbol and place a lot of premiums on it. This symbol is known to be the most

popular of all Adinkra symbols to be adopted for various purposes. It further highlights the deep connection many Ghanaians have with religion and the believe in God.

Adinkrahene (King of all Adinkra) (see Fig. 4) is tagged as superior to all Adinkra, since most of the symbols were developed following inspiration from this symbol. It goes on signify the immense role of leadership and direction. Osram ne Nsromma (The moon and the star) (see Fig. 5) tells a story of the love, loyalty, and understanding that exists between a man and a woman. It highlights the myth of the “sky’s relationship with the moon”. This symbol has been adopted for textile printing and on various substrates for commercial and religious purposes.

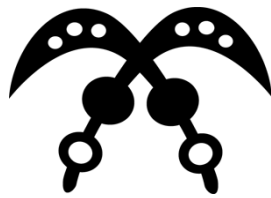


FIGURE 1:
“AKOFENA”
(Sword of War)



FIGURE 2:
“AKOMA”
(The Heart)



FIGURE 3:
“GYE NYAME”
(Only God)



FIGURE 4:
“ADINKRAHENE”
(King of all adinkra)



FIGURE 5:
“OSRAM NE NSROMMA”
(The moon and the star)

TRADITIONAL ADINKRA SYMBOLS AND BIPV APPLICATIONS

The idea of replacing conventional building materials such as roof, windows and façade makes it incumbent to consider especially the taste of consumers when it comes to aesthetics. Although issues such as cost, efficiency etc. are greatly considered, aesthetics cannot be underrated when it comes to buildings especially in this modern day. Buildings go beyond the “safe space” to contain people. Value is placed on the overall beauty of building materials hence if solar PVs are to replace conventional building materials, the aesthetic premium cannot be underrated. To a large extent, BIPV can be tagged as aesthetically appealing and attractive as compared to other variants of PV applications used directly on buildings. However, to specifically promote the adoption of BIPV by specific countries, it is important to explore specific epitomes of beauty that appeals to the people.

This aspect of the paper shall explore how Adinkra can be replicated on BIPVs to enhance its appearance and hence appeal to Ghanaians. The researchers assessed selected Adinkra symbols and buildings in Ghana with the aim of developing illustrations that blends these Adinkra symbols with BIPV. The novelty of the illustrations produced in this paper is believed to be essential for the promotion of BIPV adoption in Ghana considering the cultural attachment and connection Ghanaians have with these symbols. Graphic design illustration tools such as Adobe illustrator and photoshop were used to render selected buildings with BIPV edited to demonstrate Adinkra symbols embedded on these symbols as seen in figure 8.



FIGURE 6: An illustration of BIPV building with Adinkra symbols embedded.

Figure 6 above demonstrate the use of “Gye Nyame” (Only God) symbol which is known to be one of the most popular Adinkra symbols widely known and adopted by Ghanaians for various usages. The authors are of the view that applying these traditional symbols will equally enhance the adoption of BIPVs in Ghana despite the obvious limitations.

CONCLUDING REMARKS

This paper has offered a detailed discussion on the theory of BIPV, the relevance of traditional Adinkra symbols in Ghana and its application in BIPVs. Popular traditional Ghanaian Adinkra symbols such as “Akofena, Akoma, Gye Nyame, Adinkrahene, Osram ne Nsromma” have been highlighted as epitomes of tradition, heritage and of significant cultural relevance among Ghanaians. The “Gye Nyame” symbol has been embedded on BIPV and graphically illustrated as a prototype. Adinkra symbols can positively influence the adoption of BIPVs in Ghana and alike countries. It is recommended that BIPV manufacturers can begin to explore the option of developing customized BIPV materials to depict the tradition and culture of the targeted group of people. This can go a long way to influence its adoption. This paper is a presentation of just an idea that could lead to further research in the area and does not present conclusive evidence from collected data or study conducted within a geographical context.

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