Colours and Shapes—Perspective from Ghanaians on BIPV Aesthetic Optimisation

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Abstract—Colours, texture and shapes of Buildings Integrated Photovoltaic (BIPV) have been fully explored in recent times to match mainstream architectural aesthetics. This study aims at getting some perspectives from Ghanaians when it comes to the colours and shapes of BIPVs. A quantitative method was used to reach out to 410 respondents in Ghana. 94.1% of the respondents agreed to adopt BIPV should there be a variety of colours, textures and shapes. The outcome indicates that aesthetic optimisation, in terms of introducing a variety of colours and shapes, tends to increase adoptability. Colours could be a top priority when it comes to BIPV in Ghana, as indicated by 65.8% of the respondents. 68.9% prefer bright colours, while 31.1% prefer dark colours. This study is expected to advise BIPV stakeholders on the aesthetic interest and preferences of consumers.

Keywords—Buildings Integrated Photovoltaic (BIPV), solar energy, aesthetics

I. INTRODUCTION

Climate change and its catastrophic repercussions call for a pragmatic approach to convert the world into a clean space, where carbon levels will reduce, and sustainable practices shall become the new norm. The built environment alone contributes to about 40% of CO2 emissions, therefore, requires immediate intervention. Enforceable laws have been enacted in Europe and other countries to ensure buildings meet a specific standard; however, the level of success is debatable [1]. One approach is the introduction of Building Integrated Photovoltaics (BIPV), where solar photovoltaics are used to replace conventional building materials, either for roofing or facade.

One of the major differentiating factors between BIPV and its counterparts building applied photovoltaics (BAPV) is architectural salience [2]. In other words, BIPV blends into the architectural envelope of the building; hence consumers are more conscious of its appeal. The real need goes beyond mere energy efficiency as the PV functions as both a building material and a source of electricity [3]. In the BIPV world, the aesthetic is indispensable, hence it is critical to consider consumer perspectives when it comes to fundamental elements of design; colour, shape, and texture and how they affect adoption. In general terms, product preference has been mostly accompanied by appearance [4]. Consumers are keen on the appearance of everyday consumables and technical products [5]. The aesthetic outlook of a particular product engages the emotions of consumers and can convey the efficiency of a product. Interestingly studies have proven that products perceived to be beautiful are believed to be better without necessarily using the product to verify [6]. Product aesthetics has therefore been prioritised as much as functionality considering its stakes in adoption, including building materials.

II. LITERATURE REVIEW

For facades, the aesthetic outlook of BIPV is critical and remains challenging for developers as the demands keep changing [7]. In the minds of consumers, elements of aesthetics such as colour, texture, and shape are critical to select BIPV for their buildings. Several studies have identified architectural aesthetics as a major limitation for BIPV adoption [8]–[10], with a particular focus on colours. Thanks to advancements in technology, BIPV colours, texture and shapes have been explored in a broader context to match or perhaps overtake modern architectural materials, as seen in Figs. 1 and 2.

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In many cases, most coloured or textured BIPV modules come in a multilayered structure, where the layer containing the colour or texture is formed on top of the existing PV module [12]. Technically, because the colour layer absorbs or reflects some amount of the light received, energy efficiency is reduced up to over 40% compared to the conventional modules [13]. This appears to be a significant loss, hence of critical concern to various stakeholders. The focus has been to have the layer built-in to reduce energy losses. A study conducted by [13] highlights the additive method of manufacturing coloured BIPVs to minimise losses. Despite the potential energy loss after the introduction of coloured layers on PVs, it remains the choice for some consumers because of its beauty. For BIPVs to gain full acceptance in the architectural world, it is critical to consider the core elements of aesthetics – colour, texture, and shapes. The market perception about these elements is necessary to inform developers. Very few studies consider the aesthetics or visual appearance of solar applications in buildings [4], hence the need to fill the literature gap. This study thus presents the outcome of a survey conducted among Ghanaians to establish the aesthetic perceptions of BIPVs.

III. MATERIALS AND METHODS

This study adopts a quantitative method to assess Ghanaians’ preferences regarding the aesthetics of BIPVs. Research questionnaires were designed and distributed mainly through surveys. An initial pilot survey was conducted to about 100 respondents mainly from Ghana. However, the feedback indicated little or no understanding of the subject due to the novelty of BIPV in Ghana. The researchers, therefore, introduced infographics and demystified complex words to enable understanding, as indicated in Figs. 3 and 4. Respondents were also given the room to make qualitative entries to support the quantitative data provided.

The survey was distributed through social media, direct emails, and snowballing approach, where participants shared the survey within their circles to reach as many respondents as possible. Respondents in remote areas who could not have access to the internet were offered paper copies to enable them to make their inputs.

The retrieved data were statistically analysed by using SPSS and Excel to generate tables and graphs.

IV. RESULT AND DISCUSSION

The retrieved data were categorised into two fundamental areas. Firstly, the demographics, which mainly captured the age and gender of the respondents. The second part of the survey focused on the aesthetics of BIPV and the Likelihood of adoption. Respondents provided qualitative feedback, which was used to support the quantitative results.

A. Demographics

Gender and age are fundamental factors when it comes to product choice. The age and gender of the respondents have been displayed in Figs. 5 and 6 below. Clearly, majority of the respondents were males (58.8%) and within the youthful ages (between 20–49 years).
B. Aesthetics Preferences of BIPV

1) Likelihood to adopt BIPV because of Aesthetics

Although the primary aim of solar PV is to generate energy, BIPV has crossed carpets to become a fundamental architectural material, hence requiring meeting aesthetic specifications [7], [14]. Respondents were asked if aesthetics mattered at all when it came to their decision to adopt BIPV. 94.1% responded yes, and 5.9% said it does not matter, as seen in Fig. 7.

![Figure 7. Likelihood to adopt BIPV because of Aesthetics (Survey data)](image)

2) Likelihood to adopt BIPV if there are a variety of colours, textures, and shapes

One of the most outstanding features of BIPVs is the variety of colours and shapes that it offers. Respondents were asked if colours and shapes mattered when it came to BIPV adoption for their homes. Table I shows that 94.1% responded yes, while 5.9% responded no.

![Figure 8. Colour Preference (Survey data)](image)

![Figure 9. Shape Preference (Survey data)](image)

C. Qualitative Data—Shapes and Color Consideration When it Comes to BIPV Adoption

Respondents were given the room to make qualitative input. 13 respondents commented on their preferences when it comes to shapes and colours for BIPVs and their rationale. In Table II below, respondents have been represented with R (R1–R13).

![Table II. Qualitative Results](image)
This study is expected to inform BIPV stakeholders, especially manufacturers, about taste preferences and some perspectives from consumers.

**CONFLICT OF INTEREST**

The authors declare no conflict of interest.

**AUTHOR CONTRIBUTIONS**

SA conducted the research and prepared the first draft; NS edited and prepared the final draft; all authors contributed to the design of the research and approved the final version.

**REFERENCES**


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