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ARCHITECTURAL INTEGRITY UNDER SOLAR INTEGRATION: A VISUAL AND SPATIAL ANALYSIS OF ROOFTOP PHOTOVOLTAIC DISRUPTION IN URBAN ARCHITECTURE OF LAHORE

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Abstract

Rooftop photovoltaic (PV) systems in Lahore are typically installed after building completion rather than integrated during the design process, compromising architectural integrity and producing visual and spatial conflicts at street level. Although local regulations such as DHA Lahore's byelaws on panel height and installation exist, they are limited in scope and do not consistently address architectural integration at the national level. Existing research in Pakistan has predominantly evaluated rooftop PV systems through energy generation, cost and technical performance, while architectural compatibility and spatial quality remain largely unexamined. This study investigates the architectural causes of post-completion rooftop PV problems in Lahore and proposes design approaches that support renewable energy adoption without compromising building design principles.Four objectives guide the research: to examine street-level visual disruption; to assess the impact of panel height on roof usability and appearance; to explore stakeholder perceptions; and to propose design-based recommendations. These objectives inform four research questions concerning visual disruption, spatial and functional impacts, stakeholder opinions, and design integration. A qualitative multiple case study strategy is adopted. Cases were selected based on visible PV installations, location along major roads and variation in architectural style. Data were collected through open-ended questionnaires with architects, residents and building owners; semi-structured interviews with practising architects; and photographic documentation from pedestrian viewpoints. Triangulation strengthens the credibility of the findings. Thematic analysis was employed to identify themes including visual disruption, architectural language conflict, roof usability trade-offs and the absence of solar integration in design. Trustworthiness is addressed through credibility, transferability, dependability and confirmability, while ethical considerations include informed consent, anonymity, confidentiality and the right to withdraw. The findings are expected to clarify the tension between energy performance and architectural aesthetics in Lahore's urban context and to offer practical guidance for architects, urban planners and policymakers.

Keywords: Architectural Integrity , Solar Integration , Visual and spatial analysis, Photo voltaic Disruption, Urban Architecture

1.INTRODUCTION

The increasing integration of renewable energy technologies into the built environment has created new opportunities and challenges for contemporary architectural practice. Rooftop photovoltaic (PV) systems contribute to building-level electricity generation and support the transition towards low-carbon urban development. However, their installation also raises questions concerning architectural integrity, visual coherence, spatial functionality, and the relationship between technological interventions and the existing built environment. These considerations become particularly significant when photovoltaic systems are installed on completed buildings without being coordinated with the original architectural design.

Recent scholarship increasingly recognizes that photovoltaic systems can function as both energy-generating technologies and architectural components.

In 2023, Basher and others looked into the aesthetic difficulties which are a part of building-integrated photovoltaics (BIPVs), noting the significance of reconciling energy creation with aesthetics. Likewise, Constantinou and others (2024) studied BIPV technologies with respect to urban sustainability and architectural integration. More recently, the reviews in 'Nature Reviews Clean Technology' stressed the dual functional and architectural role of BIPV, while also identifying factors such as aesthetic customization, professional expertise, and design coordination as important for the wider acceptance of BIPVs (Building-integrated photovoltaics, 2025). Therefore, these developments reaffirm the importance of exploring solar integration beyond its technical feasibility. In Lahore, it is of high importance to study the relationship between the installed rooftop PV systems and architectural styling in terms of visibility, mounting height, usability of the roofs, and perceptions of relevant stakeholders. In this research, a qualitative analysis of urban buildings is conducted with the aim of discovering the factors behind the architectural integrity of rooftop solar installations and possible ways of designing the successful integration of the installations.

1.1Understanding of The Connection Between the Research Problem, Objectives and Questions

The research problem indicates that the installation of rooftop PV systems in Lahore occurs after the completion of buildings, which leads to conflicts both visually and spatially. To solve that issue, four research objectives are formulated, which are searching for the degree of visual disruption from the streets, learning what the height of panels means for roof utilization and appearance, obtaining information about stakeholders' opinion and suggesting design solutions. All of these objectives can easily be expressed in the form of four research questions: the first question concerns visual disruption, the second is related to spatial and functional consequences, the third encompasses the matter of stakeholders' opinions and the fourth focuses on design integration.

1.2 Research Questions:

1: How do street views of rooftop photovoltaic (PV) systems challenge the architectural authenticity of urban structures in Lahore?

2: How does the verticality and placement of PV panels influence roof functionality and architecture?

3: What attitudes do architects, people living in urban districts, and property owners hold towards solar technology and building design?

4: How can energy generation systems be deliberately factored into architectural design considerations?

Research Context

With the tremendous amount of installations of Roof-top Photovoltaic (PV) systems in urban buildings giving rise to cleaner sources of energy and better environmental performance while at

the same time facilitating sustainable urban development, their integration raises many essential issues related to the preservation of the architectural integrity, visual coherence and spatial functionality of the places of installation of such PV systems. & the relationship between technology and the existing built environment.



Figure 1 Roof Top Photo Voltaic Systems

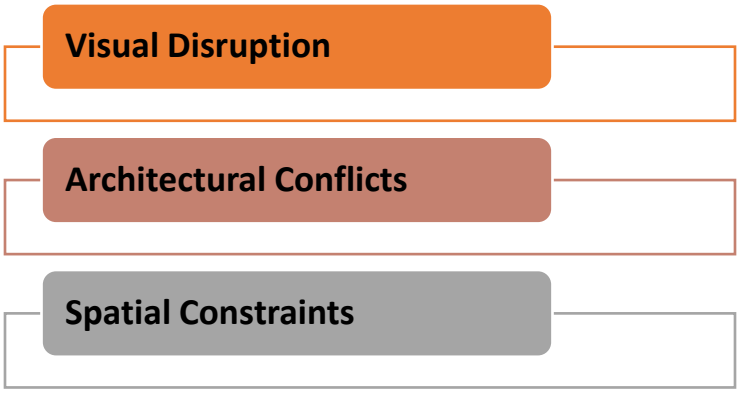
The dilemma involves making sure that solar energy system installations unify instead of diminishing the architecture and aesthetics of our cities.

renewable energy. As households, businesses, and institutions seek greater energy independence, solar panels are being installed on rooftops across cities and towns.

1.4 Research Problem

In Pakistan, rooftop solar photovoltaic (PV) systems have rapidly emerged as a practical response to persistent energy shortages, rising electricity tariffs, and increasing awareness of

Nevertheless, solar energy systems are generally erected only after the completion of the main building. Thus, PV installations are perceived as mere technical enhancements instead of integral parts of the process of designing architecture.



1.5 Research Methodology

This study comes through with qualitative research design that investigates the effect of rooftop photovoltaic (PV) integration on the architectural integrity of urban buildings in Lahore. In essence, the study points out how solar panels are usually positioned post-construction, instead of being a part of the design process itself. Since the goal of the study is to understand subjective opinions and meanings, qualitative research method is chosen as the best approach. The study employs multiple case study strategy to understand how buildings equipped with rooftop PV systems are perceived at street level. Sample buildings are chosen from Lahore based on the presence of rooftop PV systems, location near the major roads, and different architectural styles. Data is collected through open-ended questionnaires administered to architecture professionals, urban dwellers, and building owners as well as through semi-structured interviews with practicing architects and collecting photographic information from street level. Data is analyzed through thematic analysis whereby data is coded into themes such as visual disruption, conflict between architectural languages, roof efficiency trade-offs, and absence of solar integration in the design process.

The data will be analyzed using thematic analysis, which involves the coding and clustering of responses into common topics, including visual obstruction, architectural language contradiction, roof functionality trade-offs as well as lack of solar integration considerations during the design phase. A pilot study is involved to ensure the research instruments' clarity and dependability. The aspect of trustworthiness in research is taken care of through the credibility, transferability, dependability, confirmability, and other principles. Both ethical aspects are also taken care of, such as obtaining informed consent, ensuring anonymity, confidentiality and withdrawal capability. Results will provide an insight into the conflict of energy efficiency and aesthetics of architecture in Lahore.

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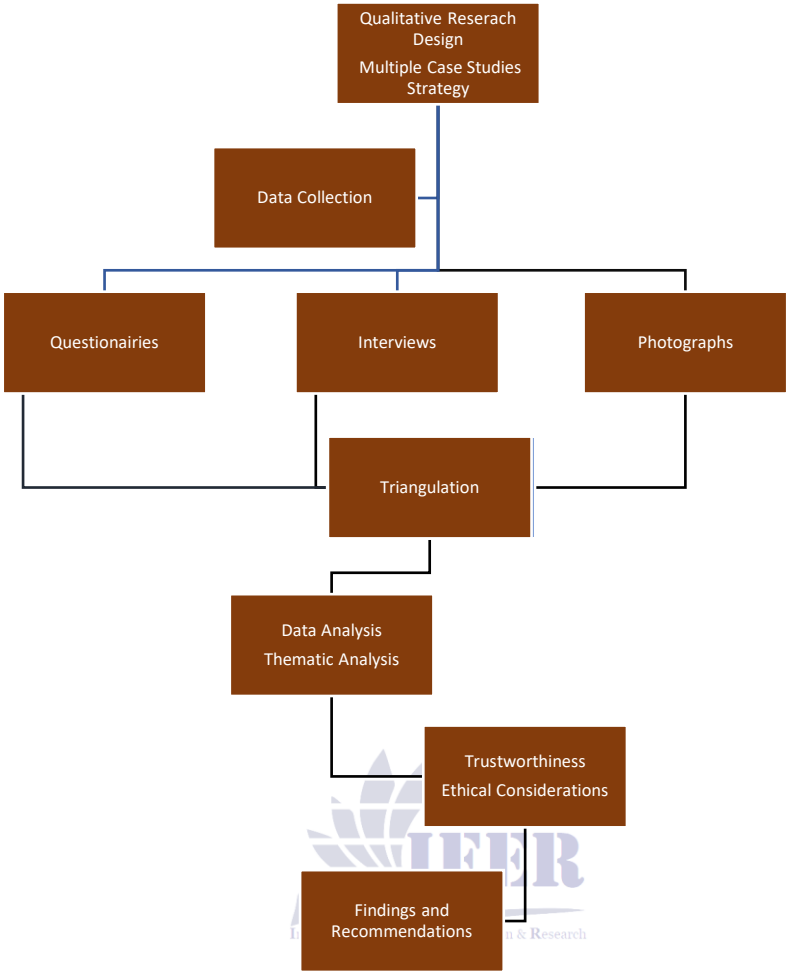


Figure 2: Framework of Research

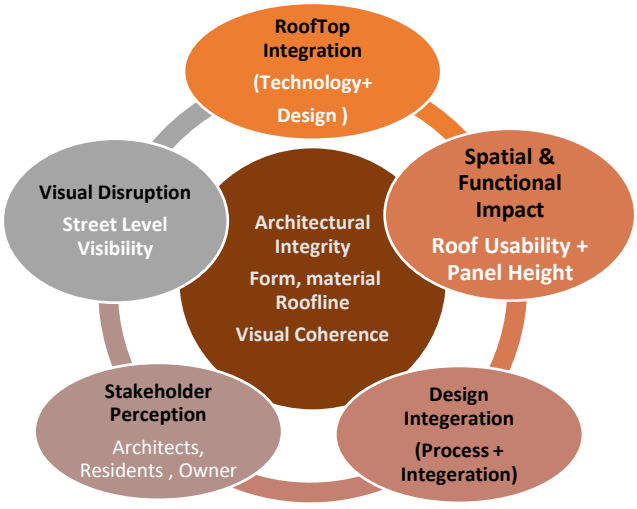


Figure3: Conceptual Framework

Research Methodology (Qualitative)			
Multiple Case studies	**Data Collection**	**Analysis**	**Trust Worthiness**
Lahore	**Questionairre**	**Thematic Analysis**	Creditability
Visible PV Systems		**Key Themes** Visual Disruption Spatial conflict Stakeholder Views Design Integration	Transferability
Various architectural Styles	**Photographic Documentation**		Dependability
			Confirmability

2.Literature Review

Literature Review: Architectural Integrity Under Solar Integration in Urban Architecture of Lahore

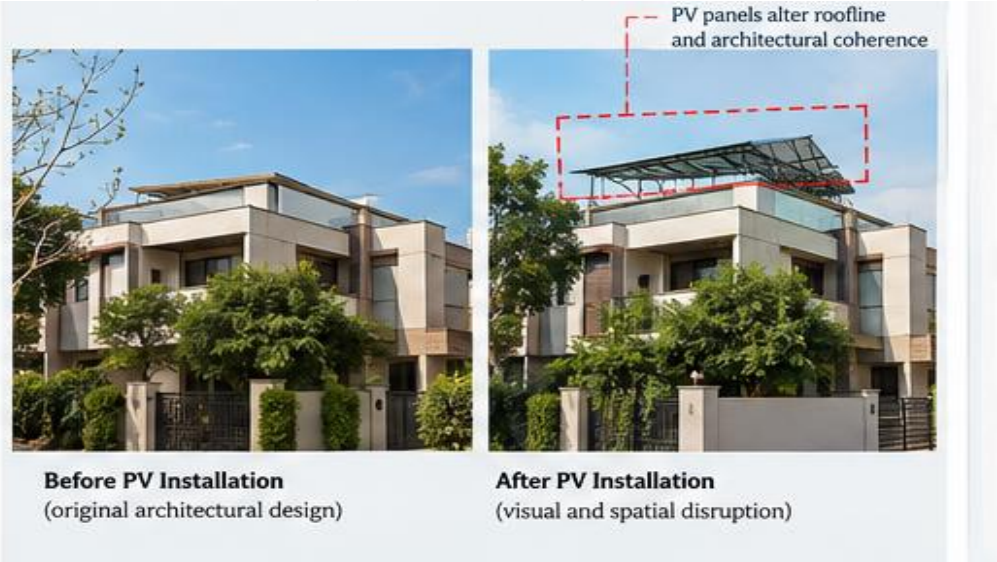


Figure 8 Before & after PV Installation

2. 1Building-Integrated Photovoltaics and Architectural Integrity

Architectural integrity is the term used to refer to the harmony of different aspects of a building's design, such as its shape, proportions, materials, roof design, façade style, etc. The addition of solar panels to a building may violate its architectural integrity if their configuration, color, or level of installation does not correspond to the overall planning of the building. However, it should be noted that such apprehensions are not applicable to every case; they depend on building type, installation method, viewing conditions, etc. Kuhn et al. (2021) discussed various design choices for building-integrated photovoltaics and described different alternatives of installing photovoltaic devices in the building's roof or façade. They have proposed an important distinction between classic building-mounted solar panels and building envelope integrated solar systems. Vassiliades et al. (2022) studied the geometrical and architectural features of active solar energy systems, stressing the significance of integration approaches and building design. These studies suggest that the architectural impact of solar energy systems depends on how their installation fits to the design of the building. Basher et al. (2023) took the topic further by addressing design-related aesthetic concerns during BIPV implementation. They pointed out the significance of visual personalization and compliance with architectural features pertaining to solar product designs in their work. Following this, another review published in Nature Reviews

Clean Technology (2025) revealed that aesthetic restrictions, lack of knowledge, and hurdles for technology implementation were the main barriers for BIPV installation. The present study will take advantage of this information to analyze the architectural integrity of the buildings based on evidence of several factors: continuity of the roofline, visibility of the panels, conspicuousness of the mounting frame, compatibility of the components in use, and the situation of the solar panels in relation to the overall style of the building.

These indicators will be applied to selected buildings in Lahore to investigate the extent to which conventional rooftop installations appear integrated with, or visually detached from, their architectural context.

3. Street-Level Visual Disruption and Urban Architectural Character

The visual influence of building integrated photovoltaic (BIPV) systems is determined not only by how these systems are structured, but also by how buildings are viewed in neighboring streets and public spots. From above, a solar installation that seems unobtrusive may become very visible from the ground in areas where BIPV supporting systems stand above parapets or otherwise create visual elements that stand out on roofs.



High Visibility **Material Contrast** **Better Integeration**
Urban Streetscape Impact

Figure 9 Visual Disruption from Street Level

Visual Disruption from Street Level	
High Visibility	Panels & Mounting Structures Prominent Above Parapet
Material Contrast	Panels Create Visual Contrast with building Materials
Better Integeration	Panels aligned with Roofline and Building Form
Urban Streetscape Impact	Affects overall character of the Street

Basher et al. (2023) say that aesthetic factors are very important in BIPV systems. Authors of the paper Myth or Gold? The Power of Aesthetics in the Adoption of Building Integrated Photovoltaics (BIPVs) also identify various factors in the visual acceptance of PV devices, such as their color, shape, texture, proportions, balance, and contrast. The authors state that aesthetic quality can help to accept BIPV, but points out that aesthetic power should be in accordance with efficiency and functionality. Borja Block et al. (2024) analyzed coloring methods in BIPV modules and described

how color, size, and shape of solar elements can affect the design of the buildings.

According to Borja Block and his colleagues (2024), the effect of color, shape, and dimensions of BIPV modules has been examined. Moreover, the authors showed the ability of the PV system to meet architectural demands while noting some limitations resulting from technological and economic factors. The importance of such observations is connected to the issue of understanding the visual connections between solar systems and buildings that differ in their façade materials, roofs, and styles of architecture. On the other hand, the studies of the aesthetics of BIPV do not give direct information about the level of visual disruption caused by traditional rooftop systems in Lahore. The current work contributes to the exploration of this issue by examining buildings from pedestrian perspectives and analyzing visibility of panels, continuity of the roofline, installation structure, difference in materials, and some other factors. This study will provide a justification for understanding the contribution of solar systems into the visual picture of the city environment**.**

4. Panel Height, Positioning, and Rooftop Functionality

The positioning and mounting height of photovoltaic panels can influence both architectural appearance and the functional use of rooftop spaces. In urban buildings, roofs may accommodate circulation routes, maintenance access, water tanks, mechanical equipment, and recreational activities. The introduction of PV installations can create spatial conflicts where the arrangement of panels or their supporting structures restricts these functions.



Figure 10 Panel Height, Positioning, and Rooftop Functionality

Vassiliades et al. (2022) examined the geometrical characteristics of solar energy systems and their relationship with architectural configurations. Kuhn et al. (2021) likewise reviewed alternative technological approaches to photovoltaic integration, supporting the consideration of different roof and façade arrangements rather than treating all installations as architecturally equivalent.

Belloni et al. (2024) reviewed BIPV technologies, including bifacial and semitransparent PV systems, and considered their electrical, optical, and thermal characteristics. Their findings reinforce the importance of evaluating solar systems through multiple performance criteria. Similarly, Martín-Chivelet et al. (2022) reviewed the energy-related behaviour of BIPV products and systems, providing a technical basis for considering the interaction between photovoltaic components and building performance.

The present study extends these considerations to the spatial conditions of rooftop installations in Lahore. It will examine whether panel height and positioning influence the visibility of installations above parapets, interrupt roofline continuity, restrict access to rooftop facilities, or reduce the

availability of functional roof space. Importantly, elevated mounting structures will not automatically be interpreted as evidence of poor architectural design; their implications will be assessed in relation to technical requirements, building configuration, and functional needs.

This approach will enable the research to distinguish between necessary installation requirements and avoidable conflicts arising from inadequate design coordination.

5. Stakeholder Perceptions of Solar Integration

The assessment of architectural integrity involves subjective judgments as well as observable physical characteristics. Architects, building owners, and urban residents may evaluate the same rooftop PV installation according to different priorities. Architects may emphasize formal coherence, material compatibility, and design intent, while building owners may prioritize energy generation, affordability, and maintenance. Residents and pedestrians may be more concerned with the visibility of installations and their contribution to the surrounding streetscape.

The study Myth or Gold? (2021) identifies aesthetic considerations as a potential influence on the adoption of BIPV, while Basher et al. (2023) emphasize the importance of developing photovoltaic technologies that respond to architectural requirements. Borja Block et al. (2024) further demonstrate the potential of color customization to improve the compatibility of photovoltaic modules with building design.

Nevertheless, these findings do not imply that stakeholders necessarily prioritize architectural appearance over energy performance. Instead, they suggest that the relationship between aesthetics and solar adoption warrants investigation across different social and professional groups.

In Lahore, stakeholder perceptions will be explored through open-ended questionnaires administered to architects, urban residents, and building owners, supplemented by semi-structured interviews with practicing architects. The research will examine how participants understand architectural integrity, whether they identify visual or spatial conflicts in existing installations, and which factors they consider most important when evaluating solar integration.

Comparing these perspectives will help establish the relationship between the physical characteristics of PV installations and the meanings attributed to them by different stakeholder groups. The resulting evidence will inform recommendations that account for both architectural concerns and the practical requirements of solar adoption.

6. Design-Led Integration of Photovoltaic Systems

Design-led photovoltaic integration represents an approach in which energy generation, architectural composition, building functionality, and environmental performance are considered simultaneously during the design process. Rather than treating solar panels as supplementary equipment, this approach considers their placement, dimensions, color, supporting structures, and relationship with the building envelope from the initial stages of architectural development.

Kuhn et al. (2021) identified a range of technological options for integrating photovoltaics into buildings, while Vassiliades et al. (2022) examined the geometrical and architectural characteristics of solar energy systems. Their work supports the development of design strategies that coordinate photovoltaic technologies with building form. Basher et al. (2023) further emphasized the importance of aesthetic customization, demonstrating the relevance of visual quality to the development of attractive solar-integrated buildings.

More recent research by Belloni et al. (2024) examined technological developments in BIPV, including semitransparent and bifacial systems, which expand the possibilities for coordinating solar energy generation with architectural design. Borja Block et al. (2024) similarly demonstrated how coloring technologies can provide additional opportunities for architectural customization. However, such solutions must be evaluated in relation to energy efficiency, durability, cost, and maintenance requirements.

For Lahore, these findings provide a foundation for developing context-sensitive design recommendations. Potential strategies include coordinating PV installations with rooflines and parapets, selecting mounting configurations compatible with the architectural composition, preserving rooftop circulation and maintenance access, and assessing panel visibility from public streets. Such strategies should be evaluated in relation to the technical and environmental requirements of individual buildings.

The present research therefore considers design-led integration as a means of reconciling renewable energy objectives with architectural integrity, rather than prioritizing aesthetic considerations at the expense of energy performance.



Figure 11 Design-Led Integration of Photovoltaic Systems

Analysis of Case Studies & its Findings

INTRODUCTION:

The subsequent four case studies analyze the architectural influence of rooftop photovoltaic (PV) installation post-construction in DHA Lahore. Each case features a contemporary residential structure where the PV panels were installed on raised steel structures after completion without keeping in mind the original design of the structure. The studies include individual properties (Case Studies 01 and 03) and urban streetscape elements (Case Studies 02 and 04) covering 1 Kanal, 7 Marla, and 5 Marla developments in newly developed stretches.

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CASE STUDY 01
Location: Phase 7, DHA, Lahore

Typology: 1 Kanal Residential House – Modern Contemporary

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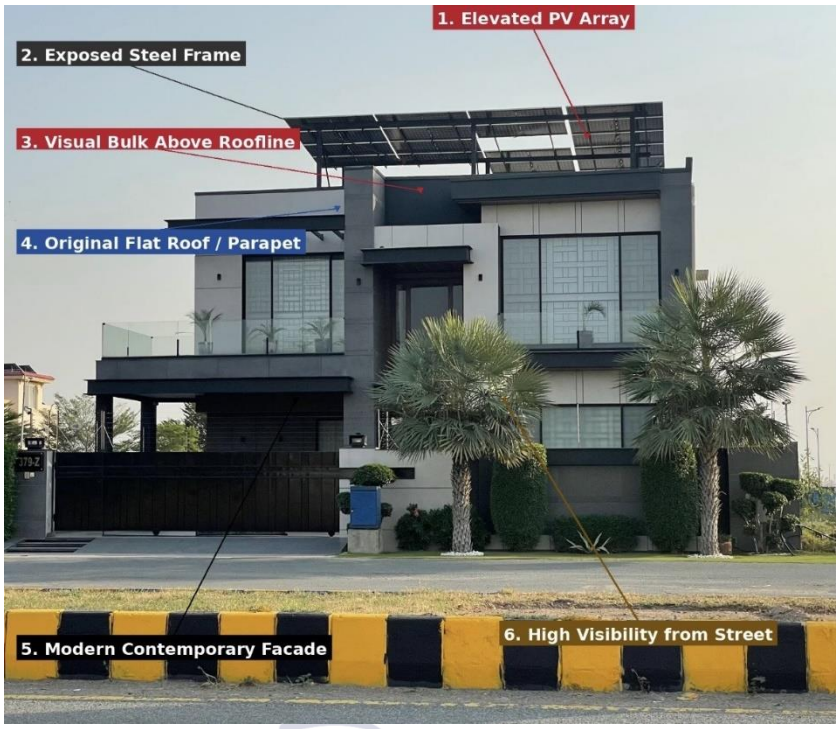


Figure 11: Case Study 01 – Post-construction Rooftop PV System

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Detailed Observations:

Post-construction Addition: PV array is mounted on an elevated steel frame approx. 10-12 ft above the parapet, not part of original architectural design.

Visual Conflict: The heavy, floating PV mass breaks the clean horizontal roofline of the modern contemporary facade and creates visual bulk.

Spatial Conflict: The elevated structure occupies potential usable rooftop space and casts shadows on the facade/roof terrace.

Lack of Integration: Exposed steel framing with no architectural camouflage or Building-Integrated Photovoltaics (BIPV) consideration. Material and geometry do not relate to the building's design language.

Street-level Visibility: The entire support structure is prominently visible from the street, degrading the overall aesthetic of the neighborhood streetscape.

CASE STUDY 02 –
URBAN STREETSCAPE
Location: Phase 7, DHA, Lahore (Main Boulevard)



Figure 12: Case Study 02 – Urban Streetscape Pattern

Typology: 1 Kanal Residential Houses
Observations (Urban Scale):
Pattern of Repetition – Not Single Case: Both Houses A (main) and B have similar elevated PV arrangements which implies that the issue concerns entire DHA Phase 7 rather than just several houses.
Structure Added After Construction: Both buildings are equipped with solar panels raised on 10-12 ft high steel structures which are not joined to the original roof.
Visual Inconsistency: Repetitive structure on top of the roof makes the skyline untidy and allows the structures to contradict the stylistic intents of the buildings located opposite.
Spatial Inconsistency: The same roof castles eliminate comfortable space for the whole stop preventing efficient usage of the roofs.
Lack of Coordination: There is neither building-integrated PV nor architectural coherence. Houses are equipped with bare steel frames and do not follow traditional design.
Urban Streetscape Degradation: The effect of a large number of high PVs on the main avenue causes visual discord in neighborhood planning.

CASE STUDY 03
Location: 9 Town DHA, Lahore
Typology: 7 Marla Residential House – Modern Contemporary

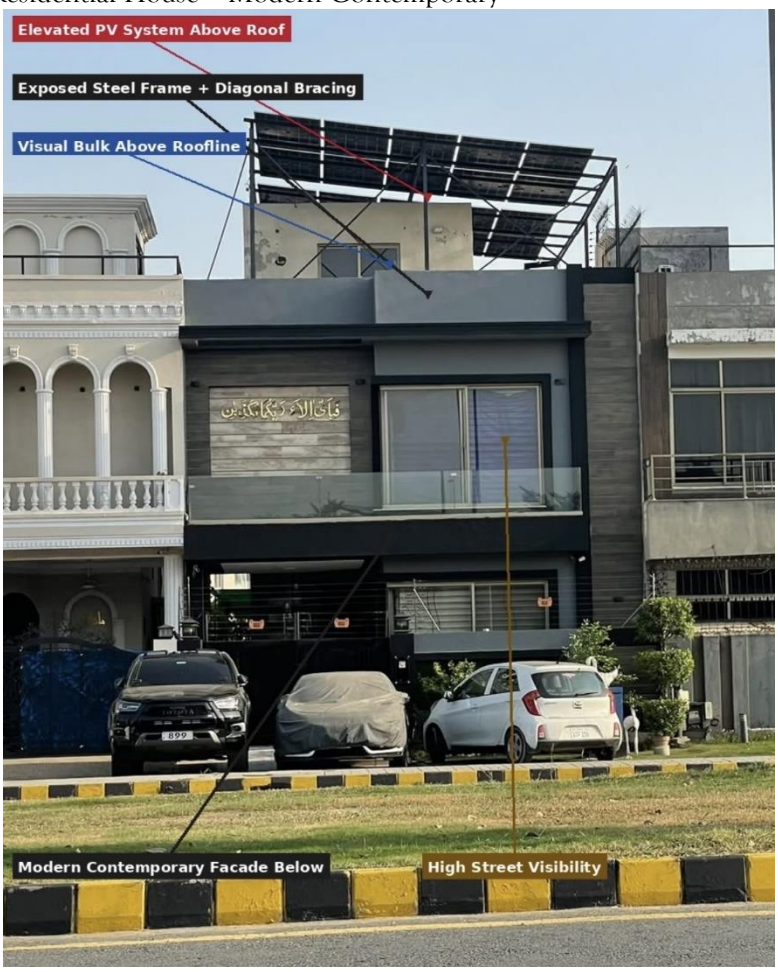


Figure 13: Case Study 04 – Post-Construction Elevated PV System (7 Marla residential)

ISSUE IDENTIFIED:
Observations:
Post-construction Addition: PV array mounted on high elevated frame with diagonal cross-bracing, placed on mumty / top room, clearly afterthought not integrated.
Visual Conflict: Massive black PV bulk floating 10-12 ft above grey parapet, dominates over the designed double-height facade and breaks the horizontal roofline.
Spatial Discrepancy: The structure occupies the whole top part of the roof, making it impossible to use for terrace purposes and casting a lot of shadow on the bottom of the facade.
Absence of Connection: The industrial steel is left visible and has not been painted to match the rest of the structure. Immense contrast with the classical facade of the neighbor on the left makes it look even worse
Visibility on the Street: The visible presence from the main road is very high because of double tilted panels connected to each other.

CASE STUDY 04 – URBAN STREETSCAPE
Location: 9 Town, DHA, Lahore
Typology: 5 Marla Residential Houses – Modern Contemporary

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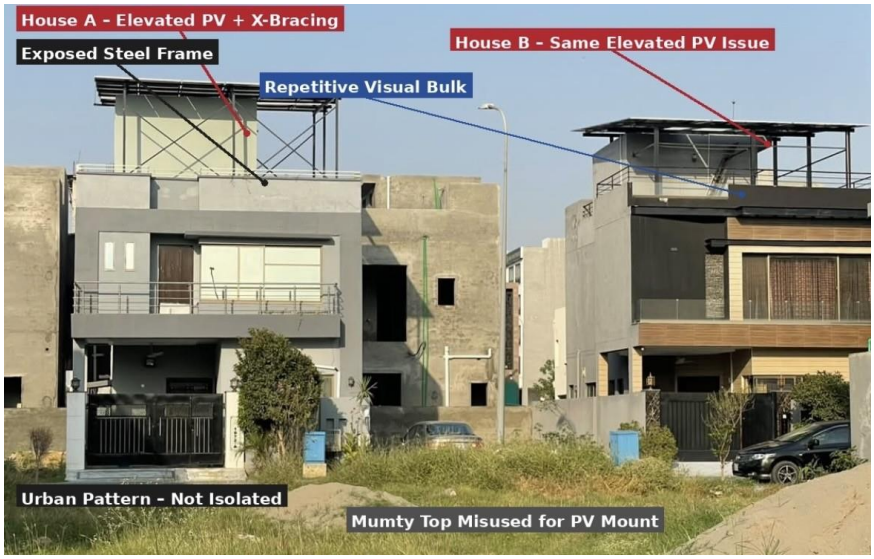


Figure 14: Two adjacent houses showing repetitive elevated PV installation – urban pattern, not isolated case, leading to visual bulk and mumty top misuse.

Observations:

Repeated Pattern- Houses A and B both possess identical raised PV structures on their mumty tops, proving the idea of systemic occurrence in the area.

Additional installation post construction- PV arrays placed on 10-12 ft high steel frames with exposed structures and X-bracing are placed over mumty and are strangely not part of original plan.

Visual Conflict- Visual masses created over the roof gives a false impression of having one extra floor, disturbing the flat roof phenomenon of contemporary houses.

Spatial Conflict- Full occupation of mumty top takes away usable roof space and gives rise to inevitable shading.

Disintegration- No BIPV or cladding. Grey industrial frames clash with grey/beige facades thus lacking aesthetic coordination.

Urban Streetscape degradation- All 2 homes on the same vacant plot road face the same problem thus proving that aesthetic degradation is common even in newly developed localities.

Table 1- Matrix comparing post construction roof top PV installations of 4 case studies in new development areas in Lahore.

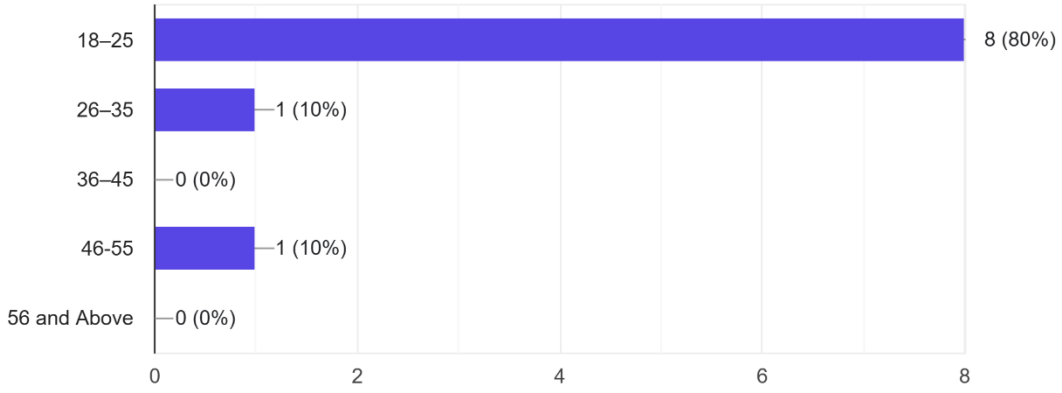
Parameter	Case Study 01	Case Study 02	Case Study 03	Case Study 04
Location	Phase 7, DHA, Lahore	Phase 7, DHA, Lahore (Main Boulevard)	9 Town, DHA, Lahore	9 Town, DHA, Lahore
Typology	1 Kanal residential house	1 Kanal residential houses (streetscape)	7 Marla residential house	5 Marla residential houses (streetscape)
Architectural Style	Modern Contemporary	Modern Contemporary	Modern Contemporary	Modern Contemporary

Scale of Study	Individual building	Urban streetscape	Individual building	Urban streetscape
PV Mounting System	Elevated steel frame, 10–12 ft above parapet	Elevated steel frames, 10–12 ft high	Elevated frame with diagonal cross-bracing on mumty	Elevated frames with X-bracing on mumty top
Construction Timing	Post-construction addition	Post-construction addition (repetitive)	Post-construction addition	Post-construction addition (repetitive)
Visual Conflict	Breaks horizontal roofline; floating PV mass	Cluttered skyline; repetitive bulk above rooflines	Massive black bulk above grey parapet; breaks roofline	Repetitive bulk adds perceived extra floor; breaks flat roof composition
Spatial Conflict	Occupies usable rooftop; shadows on facade/terrace	Uniform terrace coverage across street; terraces become energy zones	Full upper roof unusable; heavy shadow on lower facade	Complete mumty-top coverage; harsh shadows on parapet/facade
Architectural Integration	Exposed steel framing; no cladding or BIPV	No BIPV or coordination; exposed steel inconsistent with beige palette	Industrial steel, no color match/cladding; clashes with adjacent classical facade	Grey industrial frames contrast with facades; no BIPV or cladding
Street-Level Visibility	Support structure prominently visible from street	Cumulative degradation of DHA's planned aesthetic uniformity	Extremely prominent from main road; bulky industrial look from afar	Widespread aesthetic compromise even in newly developed sectors
Systemic Evidence	Isolated instance	Repetitive pattern across multiple houses	Isolated instance	Repetitive pattern across adjacent houses

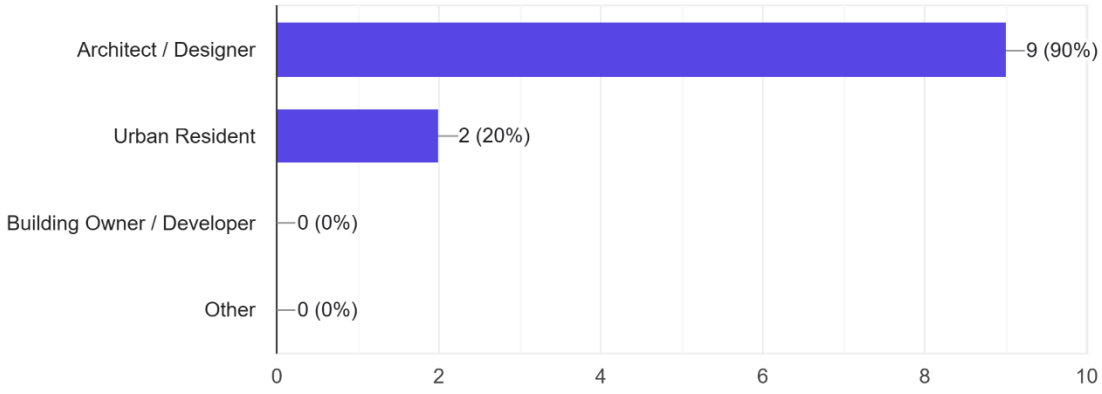
In each case, once again, the PV installations ruin the roofline and/or facade ratios along with using up the area designated for a rooftop terrace that could have served its intended purpose. The metallic framework of the PV equipment is just freely hanging without any cladding and no consideration to Building-integrated photovoltaics (BIPV) was given. Cases No. 2 and 4 reveal cases where the same equipment installation was repeated on multiple houses on one street, hence proving that this is common practice rather than an isolated case of an individual owner.

Surveys and Questionairre
Section-1 (Age & Profession)

Age:
10 responses

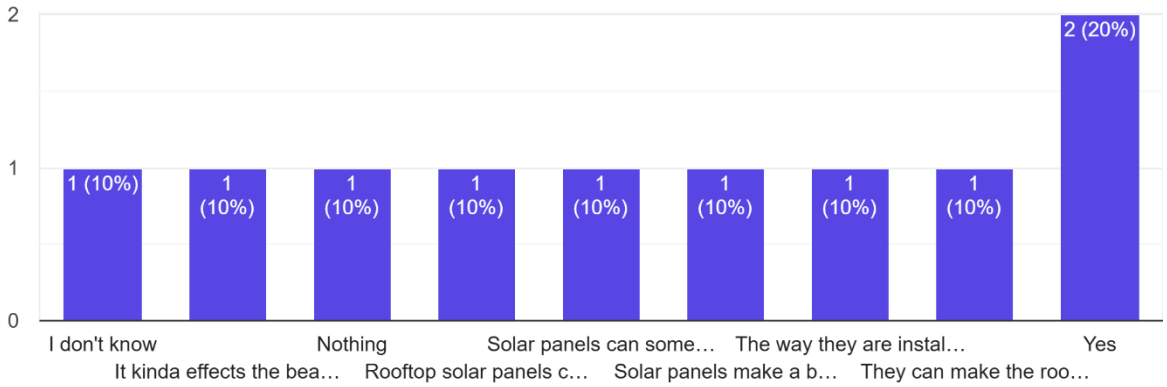


Profession:
10 responses



Section-2 Visual Impact

When you view a building from the road, how do rooftop solar panels affect your experience of its appearance?



In your opinion, do solar panels disrupt the architectural language of a building? Please explain.

According to the respondents, the consensus is that the installation of solar panels may have an impact on the original architectural features of buildings, especially in cases when the installations are not done properly. Some respondents talk about poorly installed solar panels creating challenges to reach visual harmony, symmetry, and aesthetic appearance of the building in question, especially where the building uses traditional architecture elements. However, some respondents claim that this is not necessarily the case as carefully adjusted solar panels used properly create harmony with architectural design features. One respondent was doubtful while the second one pointed out that solar panels do not look good in general.

How does the height of solar panels change the way a building looks from street level?

The interviewees confirmed that the distance of the panels from the ground has great importance in terms of their visual effectiveness. In fact, high solar panels can be seen even from the street level, which makes them more visible. Therefore, the building gets new shapes of its skyline; however, such an installation might make the whole structure look either taller or bigger than it really is because there is no longer a solution of the roof's façade. Conversely, the respondents noted that low-profile placements help blend the mounts.

Describe how a building with solar panels looks different from one without them.

From the view of the respondent, a building equipped with solar panels looks and feels high-tech and modern because of the visible panels on the roof. On the other hand, a building without them looks neat, classic, and uninterrupted. The respondent thinks that solar panels can alter the form of the building and, at times, take away from its beauty. Generally, buildings with solar panels appear to the respondent more advanced, while buildings without them look simple.

Section-3

Spatial and Functional Impact

How does placing solar panels at a lower height on the roof affect the usability of the roof space?

From the respondents' point of view, low-height solar panels occupy less vertical space and help keep the rooftop relatively open for activities such as sitting, walking, and drying clothes. They are also seen as reducing visual obstruction and preserving more usable roof space.

However, respondents noted that even low-mounted panels can restrict movement in the areas they cover and reduce the roof's usability for recreational activities and maintenance.

If solar panels are raised to allow roof use, how does this affect the building's design and appearance?

The feedback given by the respondents indicates that the general views on installing solar panels are that they can improve roof efficiency in the best way possible. However, it is accepted that if solar panels are installed above the roof level, they will also be more visible from a distance, thus changing the roofline of the building. If the panels are not properly included in the architecture of the building, they can ruin its roof visually.

In your view, is there a conflict between energy performance and architectural aesthetics? Please explain.

The respondents recognize that conflicts can occur between solar energy effectiveness and aesthetic appeal in cases of photovoltaic (PV) panels installation with a disregard of the original design of the building. Often, to increase the solar access, panels are tilted or raised, which affects the building´s appearance and architectural unity. Still, it has been said that the conflict is not inevitable because with good planning and proper placement of panels, it can solve the problem. It is reported that the real trouble lies not within solar technology but in integrating it without taking into account architecture.

What trade-offs do building owners face when installing rooftop solar panels?

The Building Owners respondents have to balance the potential for significant energy savings and decreased impact on the environment with the substantial financial cost, roof area limitations, maintenance responsibilities, and the possible effect on the building's aesthetics. While a larger solar installation produces more electricity and decreases electricity dependency from the grid, it also requires more investment capital, a larger roof area, and access to a maintenance team.

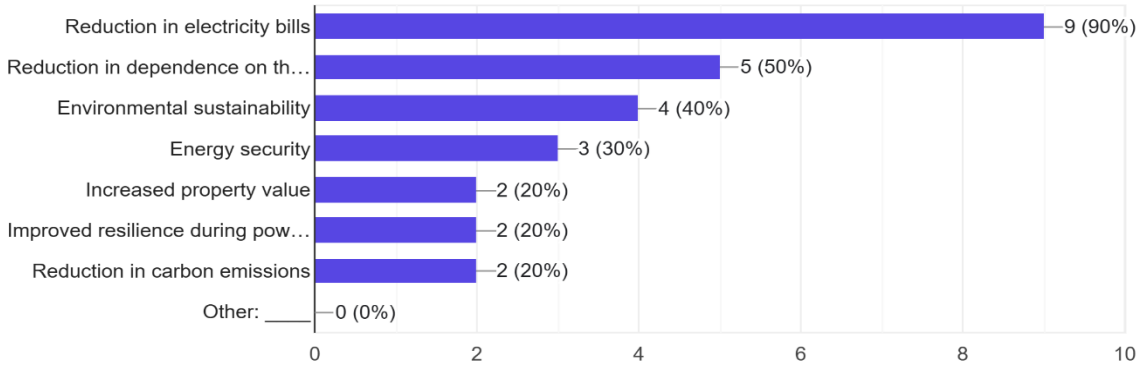
Where roof space or orientation is unsuitable, building owners may consider facade-integrated photovoltaic systems. Such systems can preserve roof usability and contribute to the building's visual design, but they typically involve higher installation costs and may produce less electricity per unit area than optimally tilted rooftop panels

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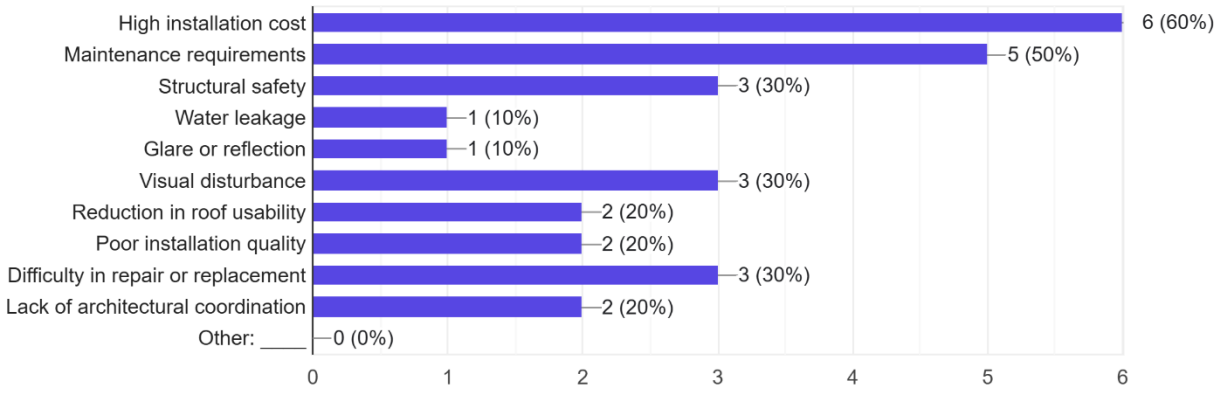
Section-4

General Awareness and Attitudes

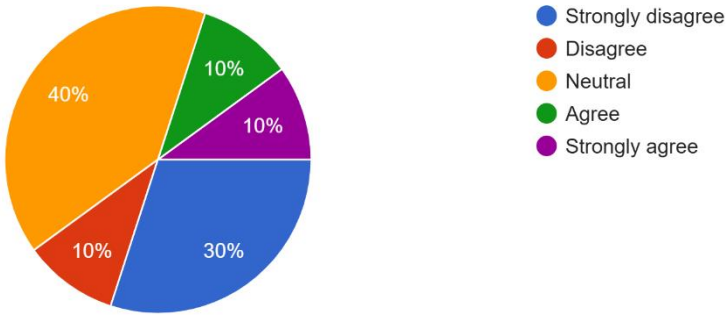
What do you consider to be the main benefits of rooftop PV systems? Select all that apply.



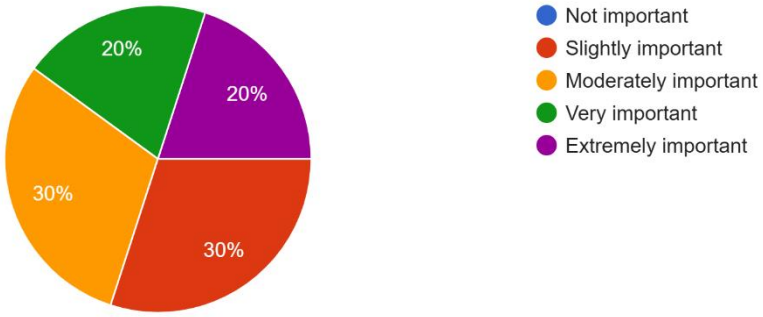
What concerns do you associate with rooftop PV installations?



In your opinion, should the environmental benefits of solar energy take priority over the visual appearance of a building?



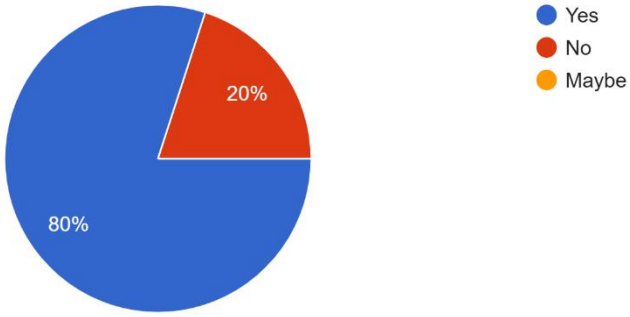
How important is the visual appearance of a building when installing rooftop PV panels?



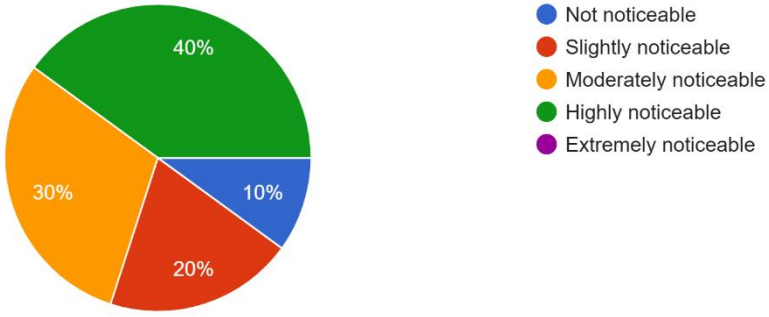
Section-5

Visual Disruption from Street Level

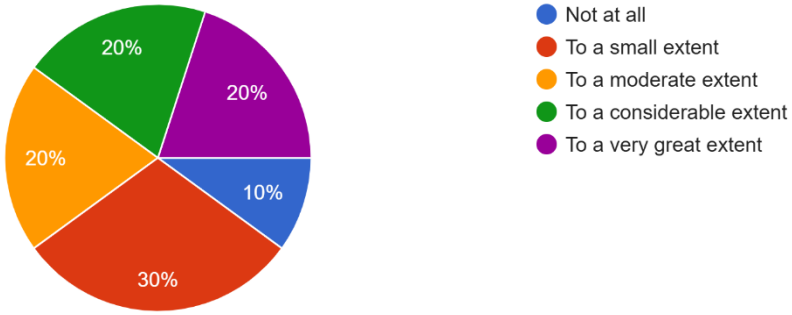
Have you noticed rooftop PV panels while viewing buildings from street level in Lahore?



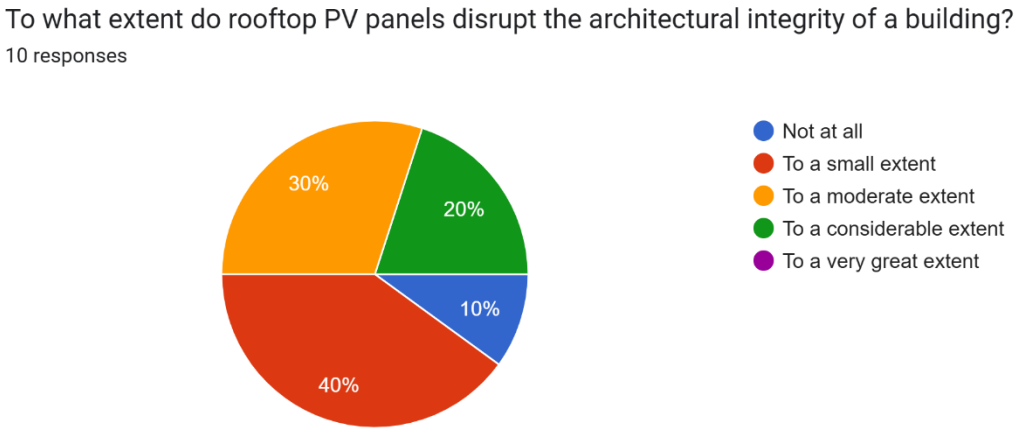
How visually noticeable are rooftop PV panels when viewed from street level?



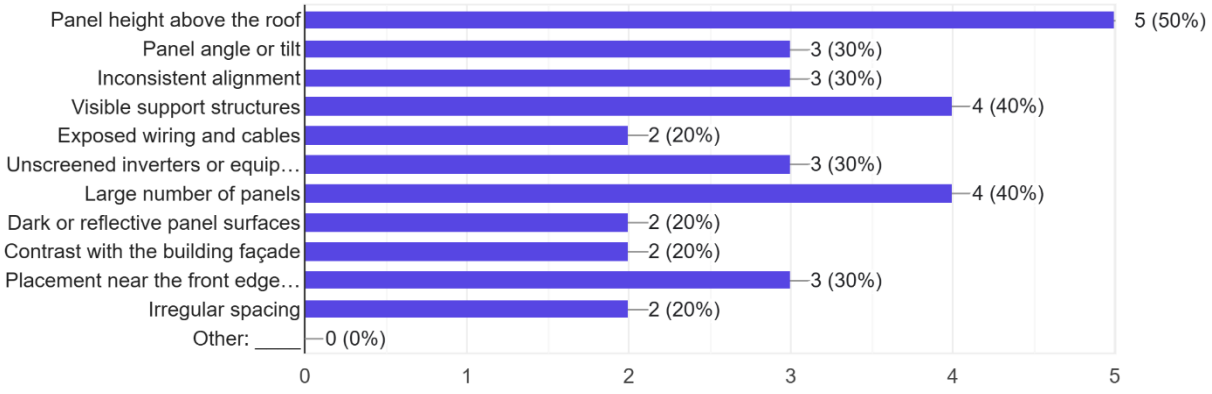
To what extent do rooftop PV panels alter the visual character of a building?



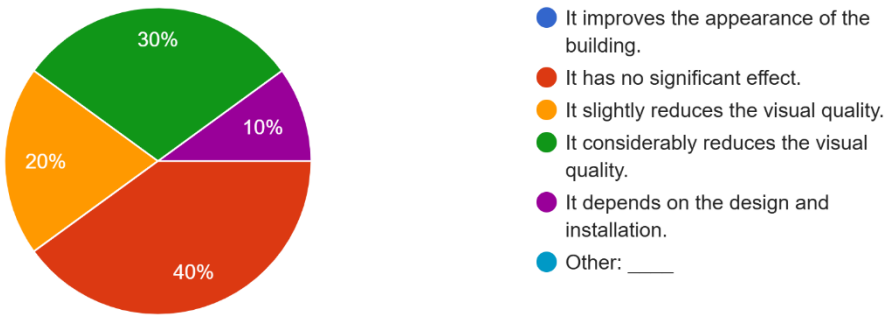
To what extent do rooftop PV panels disrupt the architectural integrity of a building?



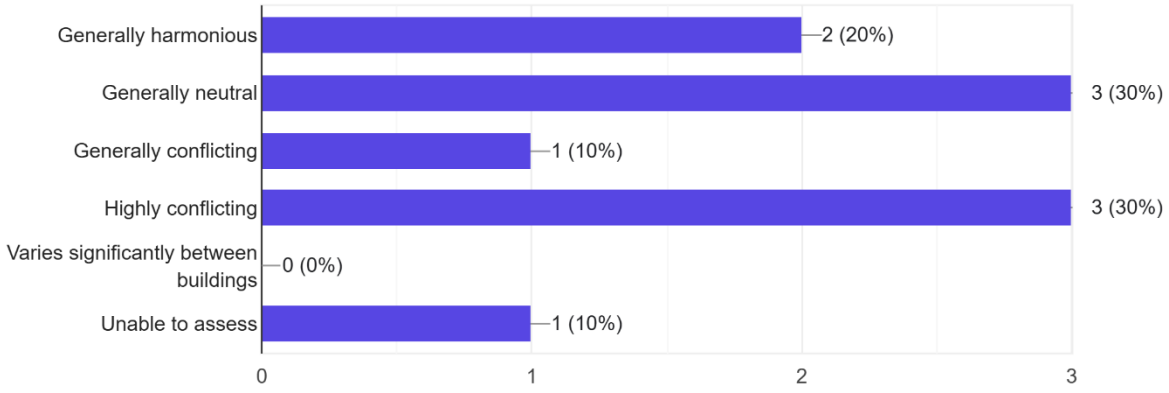
Which visual characteristics contribute most to the perceived disruption caused by rooftop PV panels? Select up to three options.



From your observation, how does the visibility of PV panels influence your perception of a building?



How would you describe the relationship between rooftop PV panels and the architectural style of most buildings in Lahore?

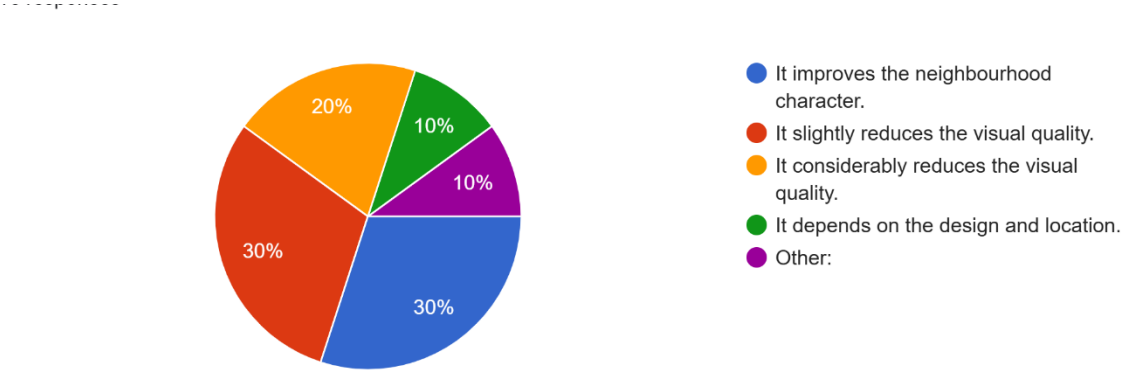


When viewed from the street, which type of PV installation appears most appropriate?

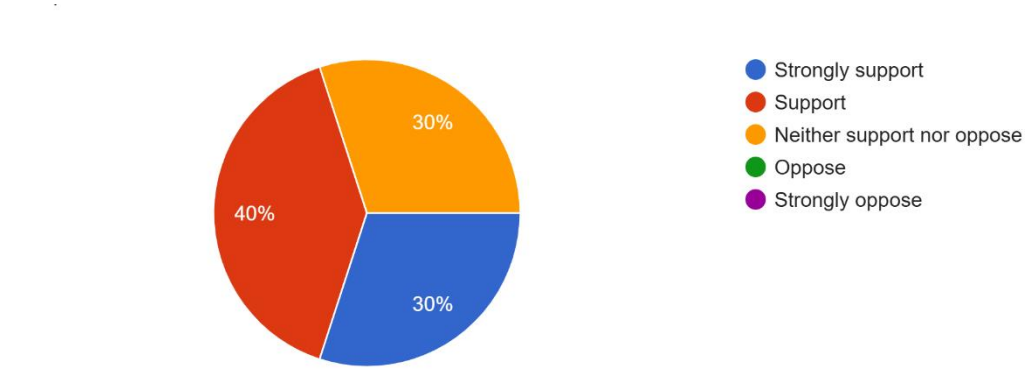


For Urban Residents

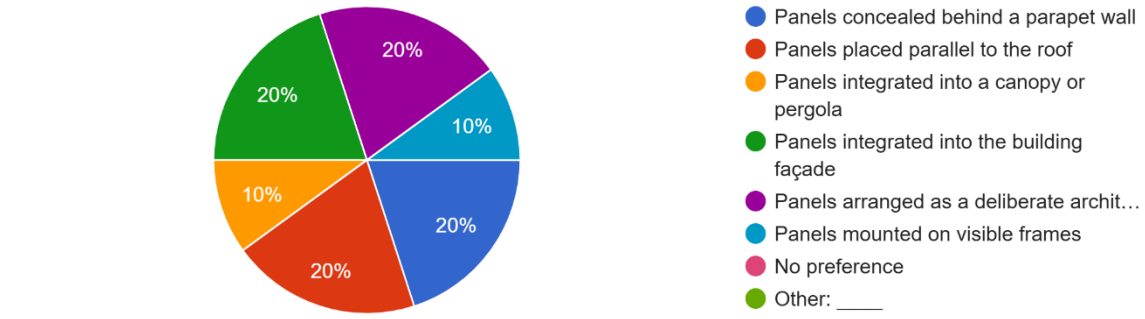
How does the appearance of rooftop PV panels affect your perception of the surrounding neighbourhood?



Would you support rooftop PV installations in your neighbourhood if they were visually integrated into the buildings?

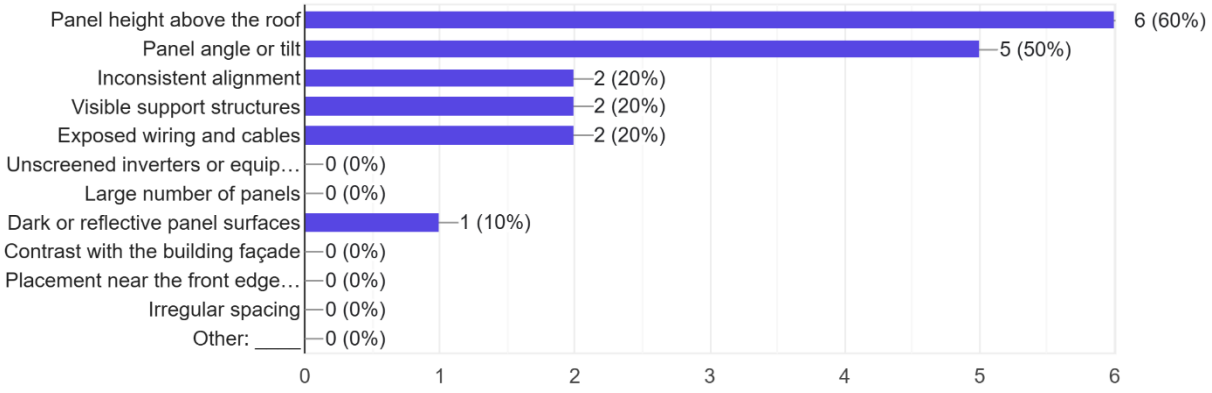


When viewed from the street, which type of PV installation appears most appropriate?

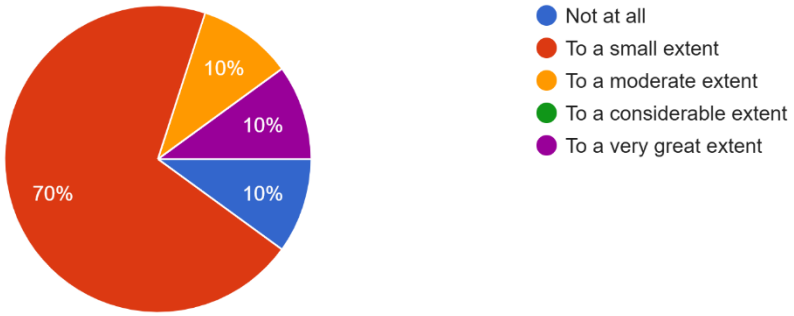


Which visual characteristics contribute most to the perceived disruption caused by rooftop PV panels?

Select up to three options.

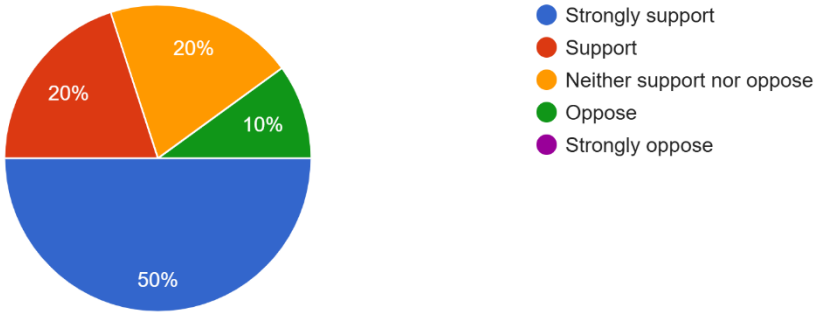


To what extent do rooftop PV panels disrupt the architectural integrity of a building?

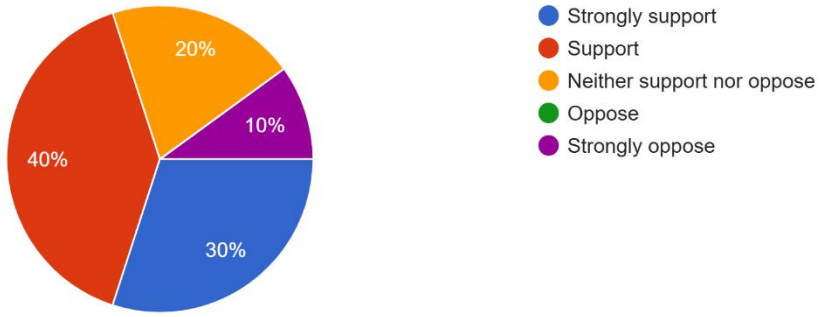


How visually noticeable are rooftop PV panels when viewed from street level?

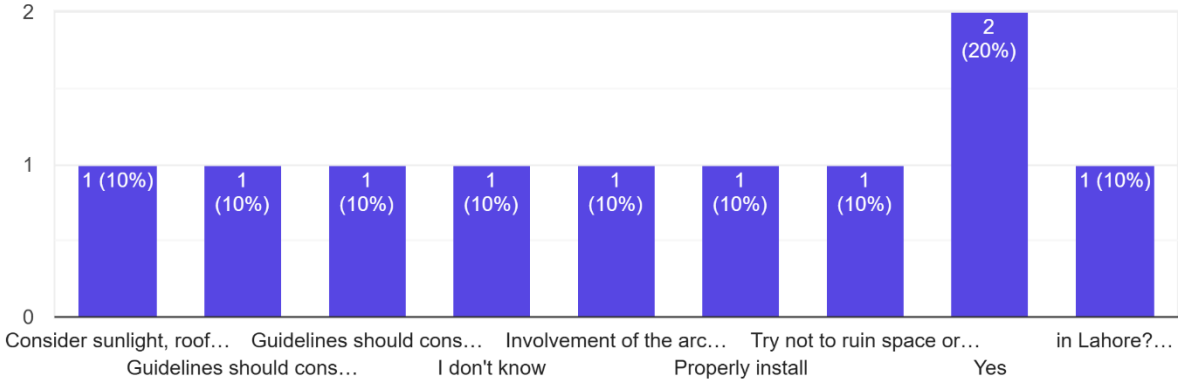
Would you support rooftop PV installations in your neighbourhood if they were visually integrated into the buildings?



Would you support regulations controlling the height, location, screening, and appearance of rooftop PV systems?



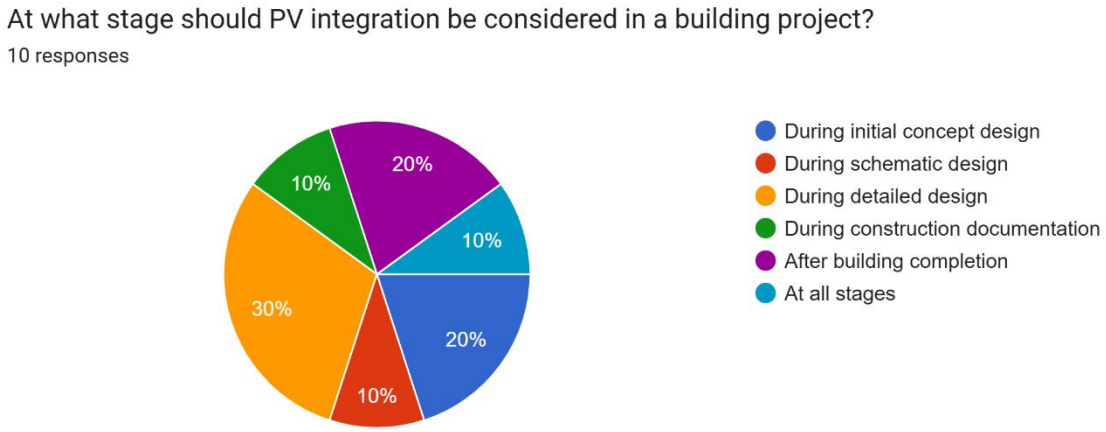
What should be considered when developing guidelines for rooftop PV systems in Lahore?



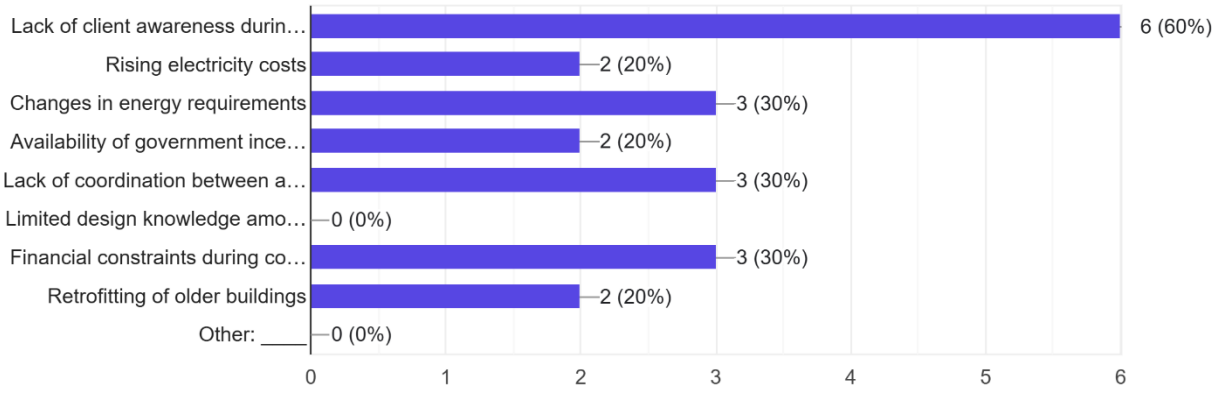
When you view a building from the road, how do rooftop solar panels affect your experience of its appearance?

Solar panels provide buildings with a modern touch and convey an eco-friendly image even if their visual effect is primarily influenced by proper design and installation. In case panels are positioned unevenly, installed too far from the roof surface, or put in a disorganized fashion, they can generate visual chaos and damage the appearance of a building. That said, rooftop solar installations in Lahore have to take into account the climatic conditions of the region, architectural style, available rooftop area, safety assessment, solar efficiency, and maintenance.

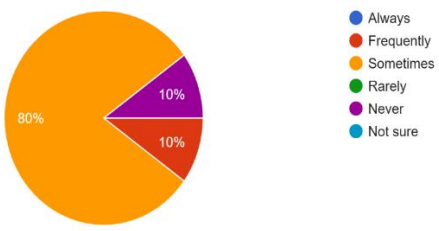
Section-7
Stakeholder Perceptions
For Architects and Design Professionals
At what stage should PV integration be considered in a building project?



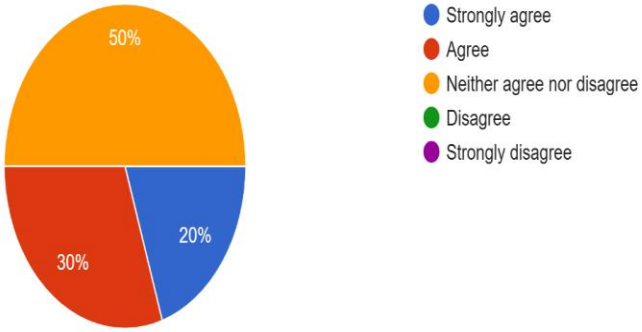
What are the main reasons PV systems are installed after building completion? Select all that apply.



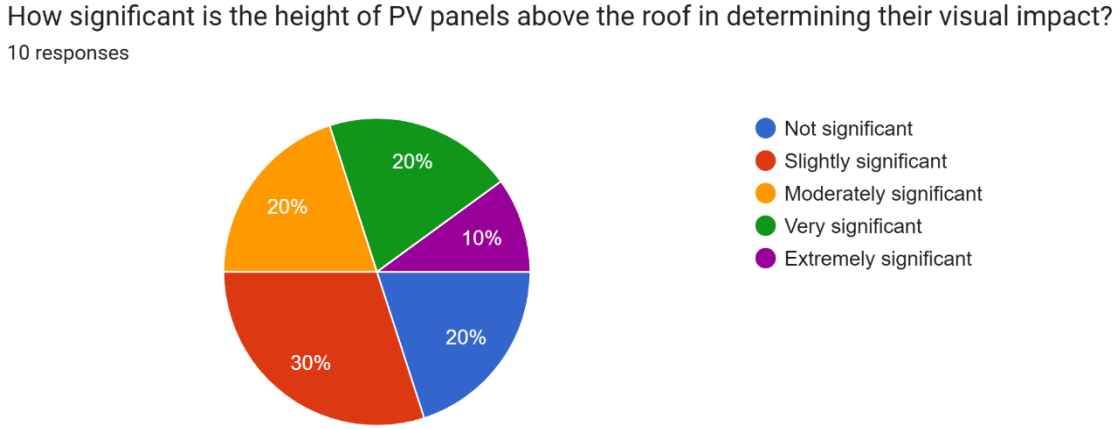
How frequently are architects involved in the selection and placement of rooftop PV systems?



Should architects be responsible for reviewing the visual and spatial consequences of PV installations?



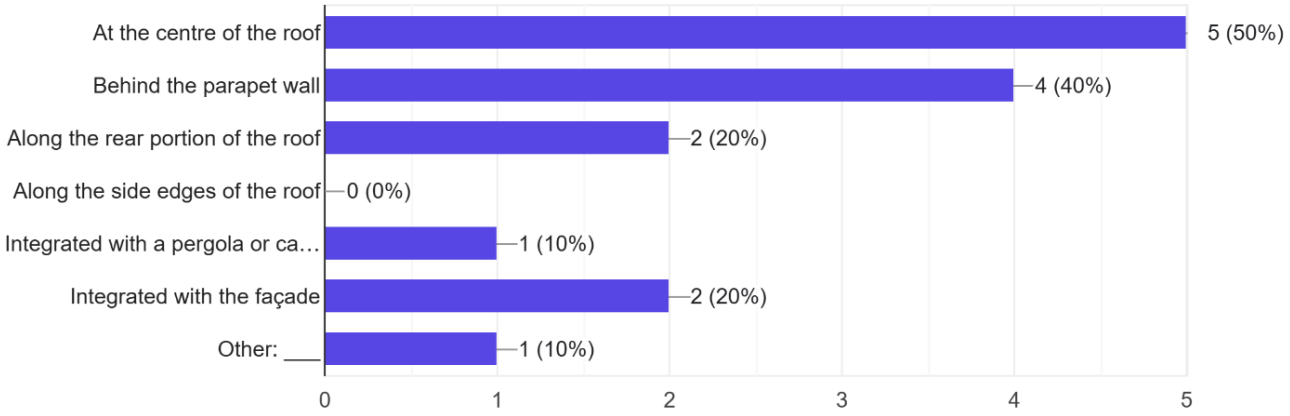
Section-8
Height, Positioning, and Roof Usability
How significant is the height of PV panels above the roof in determining their visual impact?



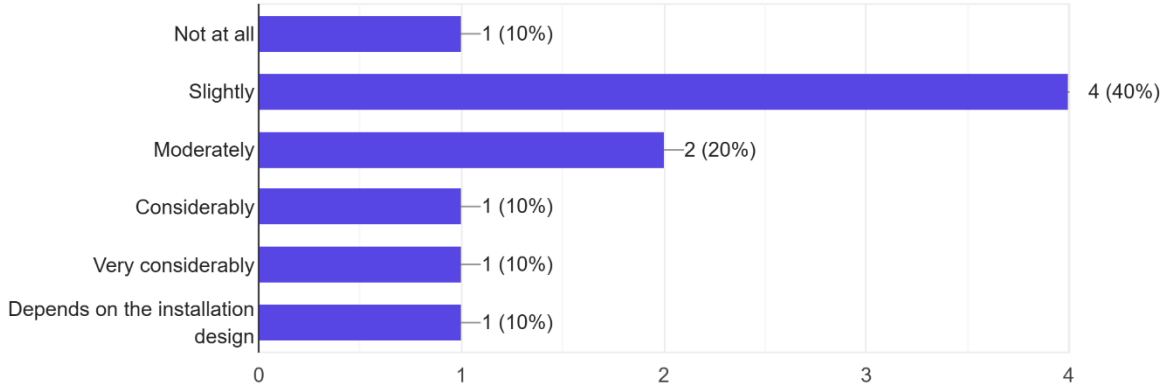
How does the height of rooftop PV panels affect the appearance of a building?

From the respondents point of view PV panels placed high on the roof are more noticeable from the street and can make the roof look bulky. Low PV panels are more aesthetically pleasing as they match the roof design better.
Higher PV panels on the roof are more noticeable from the street and make the building look bulky.

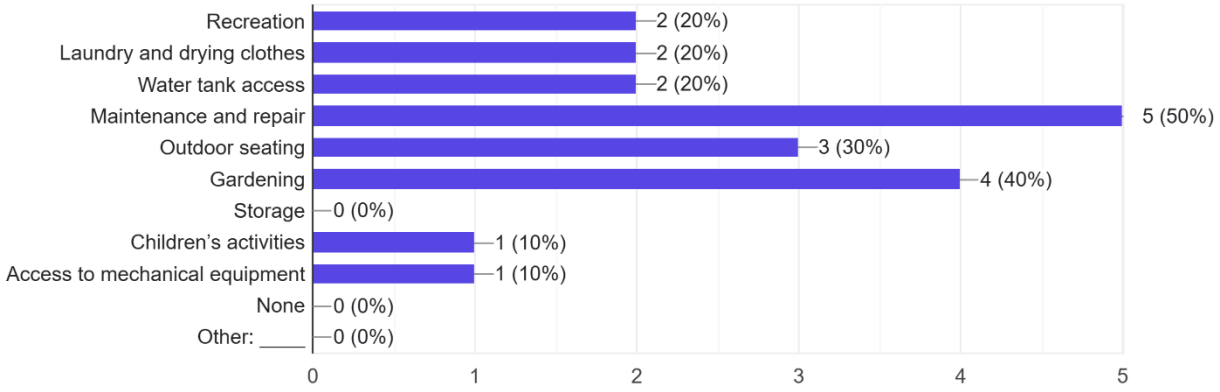
Which panel position creates the least visual disruption?



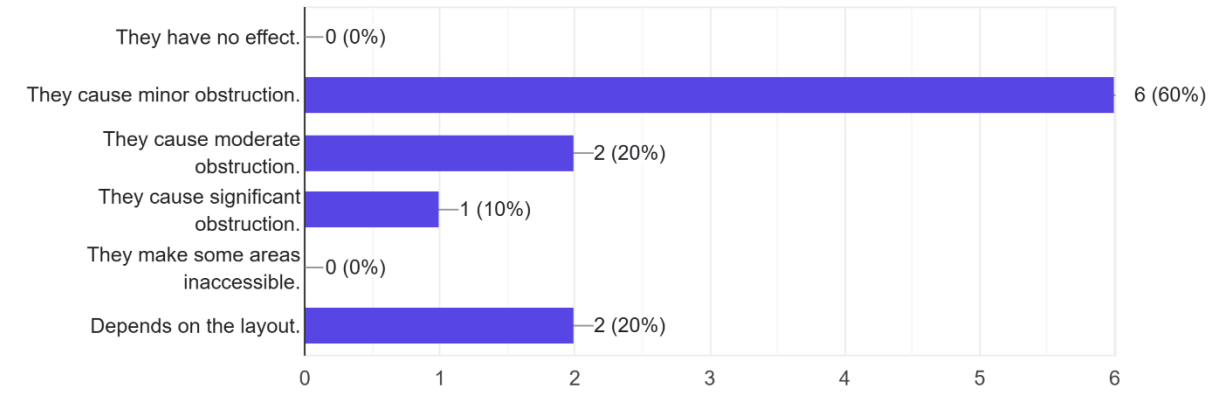
In your opinion, do rooftop PV panels reduce the functional usability of roofs?



Which rooftop activities may be affected by PV installations? Select all that apply.



How do rooftop PV systems affect movement and access on the roof?

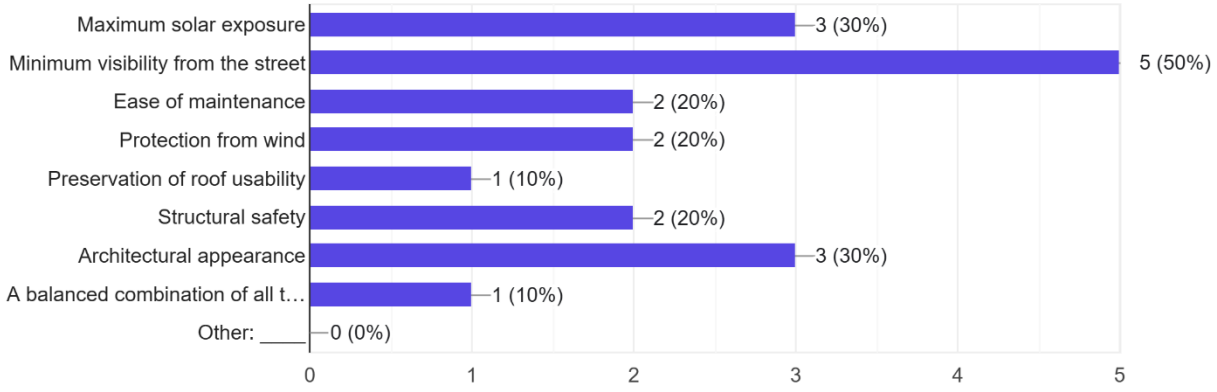


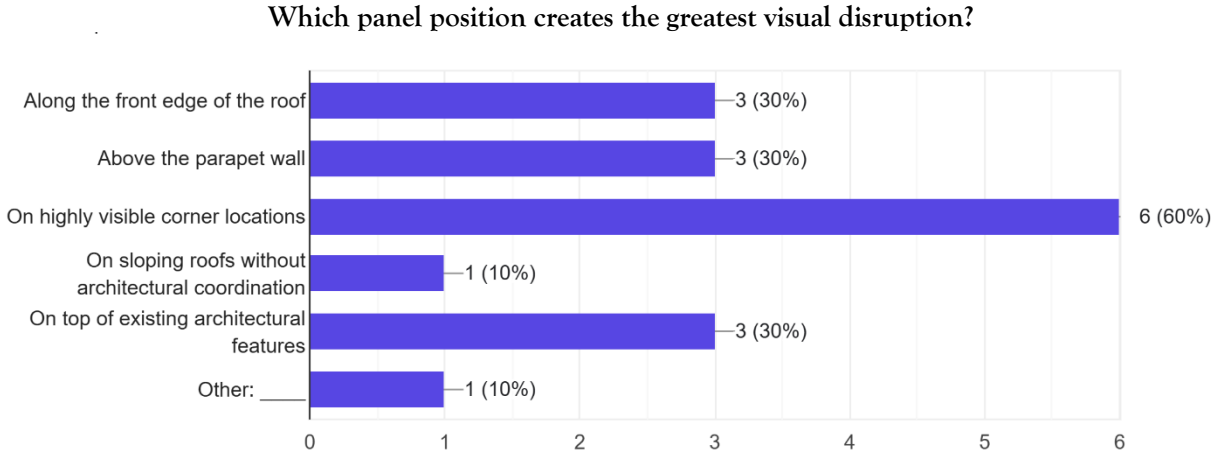
What spatial planning measures can reduce conflicts between PV panels and rooftop activities?

Zoning, providing access routes and ensuring enough space for solar panel maintenance can be achieved through proper positioning, and height of solar panels. This will ensure you get the most out of your roof.

Carefully planning the layout of solar panels on a rooftop will ensure they have been zoned correctly with plenty of access routes. Planning ahead will allow solar panels to be placed around the stairwell/mumty/OHWT area without affecting their location, or vice versa.

Which factor should primarily determine the location of PV panels on a roof?





9. Conclusion

According to recent literature, the successful incorporation of solar technologies necessitates proper integration of various aspects such as energy efficiency, architectural structure, aesthetic aspect, and space functionality. However, despite the existence of a reasonably solid basis for analyzing the technological and aesthetic features of BIPV systems, one should look into the context of traditional installations to evaluate the influence of certain architectures and cities.

The research that is presented in this article is going to analyze a number of distinctive buildings in Lahore by using photographs, questionnaires, and semi-structured interviews. Ultimately, the study will enhance knowledge regarding the connection between PV panel installation on rooftops of various buildings and their architecture.

Four case studies ponder an imminent architectural concern in DHA Lahore. Each of these scenarios includes a rooftop photovoltaic (PV) installation added after the house had been built and fixed on a platform of steel and at a height of roughly 10–12 ft above the parapet. All of these cases involved structures that were never part of the architectural scheme. The subjects of this study are 1 Kanal, 7 Marla, and 5 Marla modern contemporary buildings in Phases 7 and 9 Towns.

As a result, it is important for the Owners to find a balance between getting the maximum power from solar equipment versus conserving the unique architecture of the building. The optimal system may dominate the roof, introduce unsightly mounting equipment, or otherwise interfere with the existing design of the building whereas the less visible or integrated installation is likely to use fewer solar modules and, consequently, be less productive in terms of power.

Panels installed on optimally oriented surfaces generally produce the highest annual yield, whereas east- or west-facing installations generate less overall electricity but can improve self-consumption by producing energy earlier or later in the day.

REFERENCES

The following reference list is formatted according to APA 7th edition. The journal articles primarily cover 2021–2024, with methodological sources included to support the qualitative research design.

Basher, M. K., Nur-E-Alam, M., Rahman, M. M., Alameh, K., & Hinckley, S. (2023). Aesthetically appealing building integrated photovoltaic systems for net-zero energy buildings: Current status, challenges, and future developments—A review. Buildings, 13(4), Article 863. https://doi.org/10.3390/buildings13040863

Belloni, E., Bianchini, G., Casini, M., Faba, A., Intravaia, M., Laudani, A., & Lozito, G. M. (2024). An overview on building-integrated photovoltaics: Technological solutions, modeling, and control. Energy and Buildings, 324, Article 114867. https://doi.org/10.1016/j.enbuild.2024.114867

Borja Block, A., Escarre Palou, J., Courtant, M., Virtuani, A., Cattaneo, G., Roten, M., Li, H.-Y., Despeisse, M., Hessler-Wyser, A., Desai, U., Faes, A., & Ballif, C. (2024). Colouring solutions for building integrated photovoltaic modules: A review. Energy and Buildings, 314, Article 114253. https://doi.org/10.1016/j.enbuild.2024.114253

Braun, V., & Clarke, V. (2022). Thematic analysis: A practical guide. SAGE Publications.

Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & Quantity, 56, 1391–1412. https://doi.org/10.1007/s11135-021-01182-y

Constantinou, S., Al-naemi, F., Alrashidi, H., Mallick, T., & Issa, W. (2024). A review on technological and urban sustainability perspectives of advanced building-integrated photovoltaics. Energy Science & Engineering, 12(3), 1265–1293. https://doi.org/10.1002/ese3.1639

Kekeya, J. (2021). Qualitative case study research design: The commonalities and differences between collective, intrinsic and instrumental case studies. Contemporary PNG Studies, 36, 28–37.

Kuhn, T. E., Erban, C., Heinrich, M., Eisenlohr, J., Ensslen, F., & Neuhaus, D. H. (2021). Review of technological design options for building integrated photovoltaics (BIPV). Energy and Buildings, 231, Article 110381. https://doi.org/10.1016/j.enbuild.2020.110381

Myth or gold? The power of aesthetics in the adoption of building integrated photovoltaics (BIPVs). (2021). Energy Nexus, 4, Article 100021. https://doi.org/10.1016/j.nexus.2021.100021

Vassiliades, C., Agathokleous, R., Barone, G., Forzano, C., Giuzio, G. F., Palombo, A., Buonomano, A., & Kalogirou, S. K. (2022). Building integration of active solar energy systems: A review of geometrical and architectural characteristics. Renewable and Sustainable Energy Reviews, 164, Article 112482. https://doi.org/10.1016/j.rser.2022.112482