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Empowering Egyptian Residential Buildings with BIPV to Self-Produce Clean Energy

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Abstract

This paper discusses applications of Building Integrated Photovoltaics (BIPV) to retrofit residential buildings in Egypt to self-produce their own Energy needs, as the residential sector is the largest consumer of fossil fuels in Egypt. This requires attention to renewable Energy applications as a sustainable strategy that helps reduce the burden on the local economy, which is currently facing economic problems such as Inflation, high prices of Fossil Fuels, and a shortage of hard Currency. Also, this strategy reinforces Egypt's desire to achieve comprehensive sustainability by 2030 AD by increasing Energy production from renewable sources Such as Solar Energy, the research methodology follows an analytical theoretical approach. It begins with a theoretical study of the details of BIPV, followed by an analytical examination of residential projects that implement this concept from where the impact of these projects on Energy production and the reduction of harmful carbon emissions. Furthermore, a SWOT analysis evaluates the implementation of the integrated photovoltaic system in Egyptian buildings, aiming to provide suitable recommendations that address Weak points and threats to expanding BIPV applications. The research underscores the importance of relying on integrated photovoltaic applications in residential buildings due to their positive effects on the local economy, Individual income, and decreasing harmful Carbon Emissions. And the importance of collaborative efforts for widespread implementation across all residential buildings and others.

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1. INTRODUCTION

Countries' move towards the production of clean energy from renewable sources such as Solar Energy has become a global trend to mitigate harmful Carbon Emissions associated with the production and consumption of Fossil Fuels [1]. According to data by the NOAA Global Monitoring Lab, Carbon Emissions increased from 318ppm to 424ppm during the period between 1958 AD - 2023 AD [2], this surge directly contributes to climate change, endangering the habitability of Earth planet, BIPV Field has various options empowered architects to address energy challenges in both new building designs and the rehabilitation of existing building where Architects can seamlessly integrate Photovoltaic into buildings, enhancing aesthetics while optimizing energy production, enables surplus energy sales, contributing to cost recovery and improving individual income.

1.1. Research problem.

According to the International Energy Agency (IEA) report, the building sector's global energy consumption during the year 2022 reached about 30% of global Energy production and caused Carbon Emissions associated with Fossil Fuel consumption by 26% (8% direct emissions from buildings + 18% indirect emissions). From the production of Electricity and Heat used inside the building [1], At the local level, according to the latest reports of the Electricity Holding Company (2020-2021), Energy production from renewable sources does not exceed 5%

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of local production. The residential buildings sector consumes the largest percentage, 41.4% of the total Energy sold [3], so residential buildings must become self-reliant in meeting their energy needs and alleviate the financial strain on the state, to save required Fossil Fuels required for the operation of Electricity Power Stations serving residential regions and mitigating the detrimental impact of Carbon Emissions on the Environment.

1.2. Research goal.

Examining Building-Integrated Photovoltaic (BIPV) applications as a sustainable strategy to save 41% of Fossil Fuels consumed by the Residential Sector in Egypt and a practical solution to avoid sudden electricity shortages due to repairs or peak loads that may cause ruin Electrical Home Appliances and therefore saving repair costs. that may constitute a financial burden on Egyptian families.

1.3. Research Importance.

Promoting the adoption of BIPV applications among Egypt’s population has several positive effects:

- Reducing the chances of electrical outages as observed during the summer of 2023AD that negatively affect the daily activities of Egyptian families.
- Boosting Household Income and alleviating financial burdens resulting from the high cost of living by selling surplus electricity generated through BIPV.
- Supporting the Local Economy: by saving 41% of the non-renewable Energy demand reliance on fossil fuels and alleviating pressure on US Dollars reserves.

1.4. Research Hypothesis.

There are Successful experiments in Residential building-integrated PV in different countries to achieve the self-production of clean energy and its effect on reducing Carbon Emissions, and the Egyptian Environment is also characterized by the solar radiation required for this system to succeed.

1.5. Research Field

The research focuses on BIPV Applications in residential buildings.

1.6. Research Methodology.

The study methodology is divided into two successive stages.

- Theoretical study: By reviewing System components, Methods of connection between BIPV applications and the Electricity Grid, Photovoltaic Cell Types available in the Market, Installation Systems for BIPV applications, and factors affecting the efficiency of BIPV systems for power generation.
- Analytical study: By Analysis of residential buildings that include a BIPV application and its impact on energy production and reducing Carbon Emissions وSWOT Analysis was conducted to evaluate BIPV applications integrated into residential buildings in Egypt Then provide proposals to expand BIPV applications in design Building, especially at level the residential sector.

2. BUILDING INTEGRATED PHOTOVOLTAIC (BIPV)

It represents a trend in the field of enhancing the building’s ability to produce Energy by integrating PV Panels into the architectural design of the building, which includes Facades, Ceilings, and External elements associated with the building’s facade, such as Balustrade, Paraquet, and Canopy, or replacing traditional building materials such as Glass, Stone, Tiles, and Bricks with others that contain PV to generate Energy[4], See Fig.1.

2.1. BIPV Components and its related to Electricity Grid.

BIPV system consists of two fundamental elements PV Panels which convert Solar Radiation into direct current (DC) electricity, and Inverter which converts the direct current into alternating current (AC), Additionally, Non-essential elements may be included in the BIPV system based on its connection to the public electricity grid if the BIPV connect to the grid (On-Grid System) BIPV system include an Electricity Meter to measure the Energy sold, if the connection is Off-Grid System, BIPV system include Storage Batteries and Charging Regulators without using an Electricity Meter, If the connection is Hybrid System: the system includes an Electricity Meter, Batteries, and Charging Regulators.[5]. Fig .2. The relationship between the building and the Electricity Network is considered a vital factor in the selection process. If the building is connected to the Electricity Grid, the connection of the BIPV System to the network will be better, and vice versa. If the building is connected to an electricity network with continuous interruptions in the Electrical Current, choosing the hybrid system will be the best [6].

Fig. 1. Home 3D shows BIPV Concept

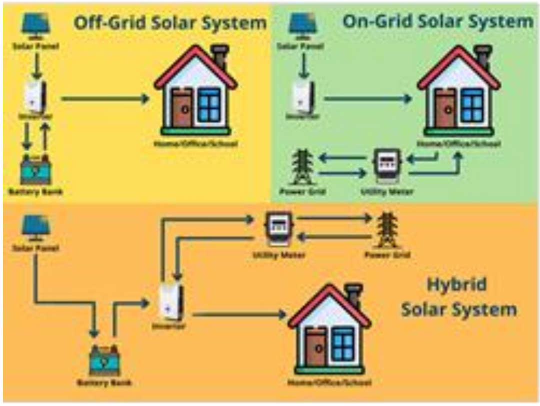


Fig.2. Sketches show Different relations between BIPV &Grid.[5]

3. PV PRODUCTS AVAILABLE IN THE MARKET

There are many options in the global and local market that the designer can use to create a PV system integrated into the building to generate clean energy, which is represented in the following options:

3.1. Traditional Silicon PV Panels.

It includes two basic types: Mono-Crystalline (Mono-Si) which consists of a single Crystal of Silicon, Black color, It has a conversion efficiency of (~20 or more) and a long lifespan, but its disadvantages are requiring large surfaces and a high cost of purchasing them [7], The other type is Polycrystalline (P-Si) which silicon fragments aligned in many different directions with Blue Color, its advantages are least expensive, most marketable, and suitable for all surfaces, but its disadvantages are less efficient at conversion (~15%) and less durable compared to Mono -Crystalline cells [7], Advancements in technology have led to the production of silicon cells with improved conversion efficiency, reaching approximately 24% or higher. As a result, the power rating of standard photovoltaic panels has increased from 250 watts to 470 watts and more [8]. See Fig.3.

3.2. PV Thin Films.

The cell consists of single or multiple thin layers of PV elements on a Glass, Plastic, or Metal substrate [9], This type is lightweight, low cost, and Easy to product operate and install, It is most widely used in PV systems integrated into buildings, specially made of Silicon (A-Si), despite the low conversion efficiency (~7-10) and shorter lifespan compared to Mono- or Polycrystalline cells, Technology contribute in increasing the conversion efficiency of thin film cells by making them from alternative materials such as Copper Indium Gallium Selenide (CIGS) (~12-14%) [10] Cadmium Telluride(CdTe) (~18-19%.) [11,12], and Organics materials and perovskites (~25% or more) [13]. See Fig.4

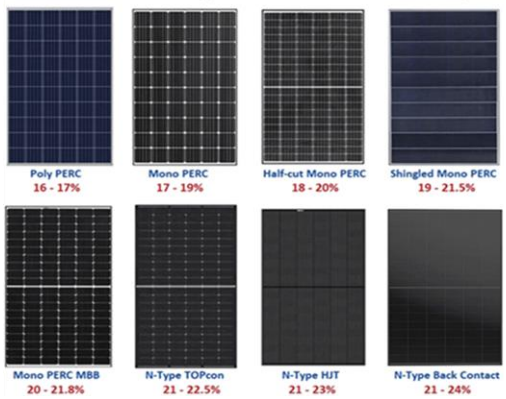


Fig. 3. Examples of Different Silicon panels more efficient [8]

Fig.4. Examples of different products of Thin Films

3.3. Transparent solar panels (TSPs).

A technology that relies on absorbing unwanted light waves to pass through windows and exploiting them to generate energy without making windows incline toward solar radiation [14], There are two types of transparent units depending on the percentage of radiation absorption that the panel does to convert it into energy. Partially transparent solar panels (absorb only 60% of passing sunlight). Completely transparent solar panels (absorb only 90% of passing sunlight).[15], various technologies are available on the market, the most common of which consists of transparent crystalline cells, which are often also modules with transparent back sides and standard crystalline cells [16] See Fig.5, The other type is transparent thin-film amorphous panels See Fig. 6 The energy conversion efficiency of these types is low compared to traditional photovoltaic systems, at about 12-15% [17].

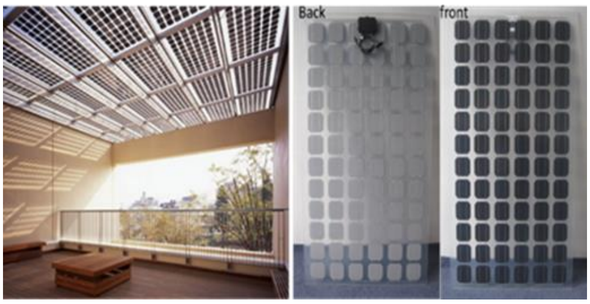


Fig. 5. Examples of transparent crystalline panels used as skylight

Fig.6. Examples of transparent Amorphous thin-film panels

3.4. Bifacial photovoltaics (BPV).

It is a rapidly growing technology that differs from typical PV panels in that it contains PV cells installed on both sides to improve the production of electricity through incident and reflected rays on both sides of the panel, thus increasing the unit's overall production during the day, See Fig.7 [18], This type is characterized by the presence of a layer of tempered glass on both sides to withstand high temperatures, strong winds, bad weather conditions, and resistance to ultraviolet rays [19]. Surface Albedo, the distance between the axes of the panels, the height of the panels from the ground, and the installation method are considered basic factors affecting the efficiency of bifacial PV panels in producing energy [20].

3.5. Photovoltaic Pavers.

Its products are specially manufactured for paving buildings' rooftops instead of traditional tiles, Entrance floors, and external Sidewalks. At the same time, it produces clean energy from Solar Radiation and achieves thermal comfort. PV market offers various options of anti-slip and multi-colored photovoltaic paving that differ in the type of PV and the amount of energy. The output/m2, the conversion efficiency, the maximum pressure tolerance, and the installation technology vary according to the producing company. An example, Onyx Solar Company produces PV Pavers that can withstand pressures equivalent to 400 kg/m2 of single-crystalline silicon (186 Watts/m2) and a conversion efficiency of 22%. Or polycrystalline silicon (158 W/m2) and conversion efficiency of 18.6%.[21], See Fig 8

Fig.7. Example of PV Canopy in Villa

Fig.8. Example of PV Paver. [21]

3.6. Facades PV products.

These products represent 20% of the BIPV market [6] such as flexible and lightweight photovoltaic modules such as Light panels, facade systems [22], Solar Brick panels Fig.9.a, which are lightweight, durable, and have brick wall-like surfaces embedded with solar modules [23], Full black modules Fig.9.b, with satin glass or float glass) to hide the PV cells inside the finishing unit, and Terracotta units Fig.9.c, with colored glass suitable for residential buildings in heritage sites [24].

3.7. Rooftop PV products.

These products represent 80% of the BIPV market [6], such as the Glazed unit Fig.10.a Tiles Fig.10.b, Shingles Fig.10.c, Foils Fig.10.d [22], These products are available in sizes, colors, and shapes similar to the corresponding traditional products, which facilitates the process of modifying the existing roof and replacing traditional units with others with integrated PV cells, achieving complete integration between these products and the form of the building.

(c) (b) (a)

Fig.9. Facades PV products available in the Market

(d) (c) (b) (a)

Fig.10. Building's Rooftops products available in the market

3.8. Outdoor PV Products.

Outdoor products integrated PV are available in the market, such as benches, Fig. 11.a, shades, Fig 11. b, and tables, Fig 11. c. whether crystalline silicon or amorphous silicon (for cloudy conditions) and have a USB port for connecting electronic devices. They are also equipped with a storage battery for use—the energy when needed [25].

(a) (b) (c)

Fig.11. Examples of Outdoor Furniture integrated PV

4. BIPV INSTALLATION SYSTEMS

The installation of BIPV systems in Residential Buildings exhibits a range of techniques. The choice of installation technique depends on the specific part of the building being targeted. Unlike Building Applied Photovoltaics (BAPV) which needed Bulk frame overload on building structure to install. These considerations are reviewed in the following points.

4.1. Roofs Integrated PV

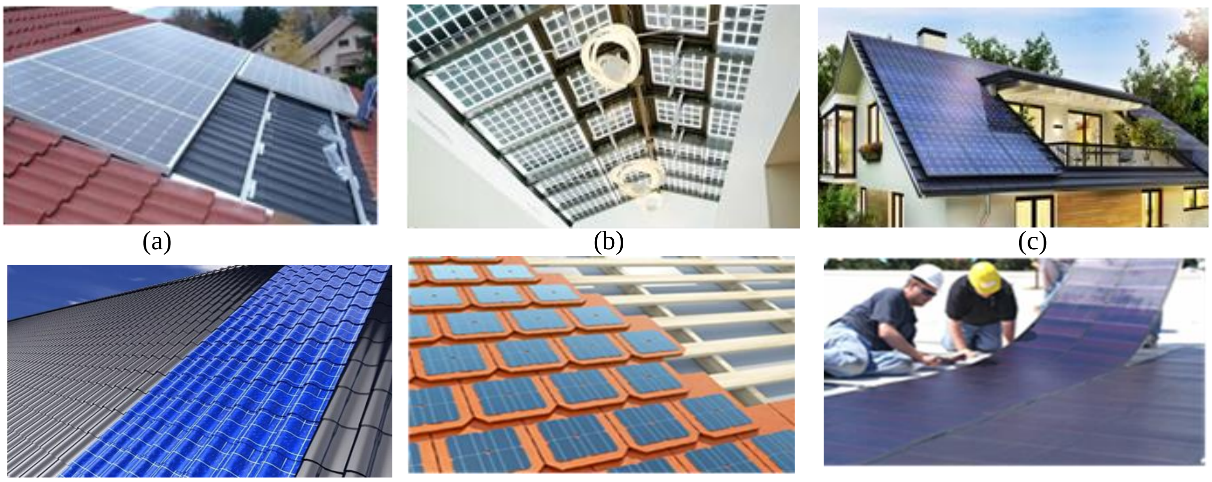
There are various techniques for Roofs integrated PV, tailored to the building's energy needs and architectural considerations:

4.1.1. In-Roof Solar Integration System: Tailored for sloped or flat roofs, where seamlessly integrated PV into a defined section of the roof structure, to become an intrinsic part of the roof itself. The installation process involves straightforward components, with an additional layer underneath the panels to facilitate effective water drainage (often utilizing an HDPE layer), Fig 12. a [26].

4.1.2. Full Roof Solution system: whether transparent Fig 12. b, or opaque roofs Fig 12. c, as the entire roof is designed as a solar energy product, and the installation system includes all the elements required for construction including frames, connections, joints, gaskets...etc. The ceiling design considers the aesthetic dimension. Mechanical loads and preventing water leaks, etc. [27]

4.1.3. Partial Replacement: The Full Roof Solution provides adaptability for both transparent and opaque roofs. In this method, targeted roof covering elements are intentionally replaced with counterparts that include photovoltaic cells Fig 12.d. or directly overlay the roof with purpose-built products Fig 12. e, ensuring seamless integration of photovoltaic cells. This technique aligns with traditional installation techniques.[27]

4.1.4. Thin Film PV Panels: Thin film PV panels play an influential role in the Full Roof Solution. These flexible panels are directly adhered to various surfaces using adhesive. Without the need for bulk frames or additional structures. Fig 12. f [27].



(a) (b) (c)

(d) (e) (f)

Fig .12. Different installation of Roofs In grated PV

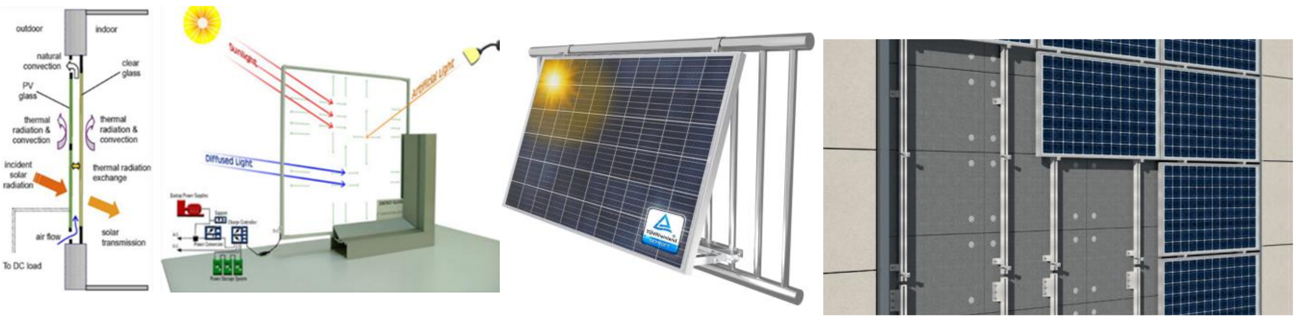
4.2 Facades Integrated PV

There are various methods for integrating PV cells into Facades, tailored to the building's energy requirements and architectural considerations.

4.2.1. PV Glass Replacement: Traditional windows can be replaced with photovoltaic (PV) glass panels, these PV glass panels serve both as functional windows and energy generators, installation techniques not different from the common technique for installation normal Glass seamlessly blending aesthetics and sustainability Fig 13. a

4.2.2. External Devices Integrated PV: Elements such as balustrades Fig13.b, Parapets, canopies, etc can incorporate photovoltaic cells using simple installation details without compromising design.

4.2.3. Facades Systems integrated PV: Curtain walls, rain screens Fig 13.c, and double-skin facades can be designed to accommodate photovoltaic panels with the same common installation details of these systems.



(a) (b) (c)

Fig13. Examples of Facades integrated PV installation details [28]

5. FACTORS INFLUENCING BIPV EFFICIENCY FOR POWER GENERATION

There are key factors that play a crucial role which can be summarized in the following points [29],[30] *5.1. Solar Irradiance:* represents a factor that strongly affects the efficiency of the photovoltaic system in generating energy. This is available in the Egyptian environment, which enjoys suitable solar radiation throughout the year.

5.2. Building Needs: this is reflected in the design of the photovoltaic system in terms of choosing the type of cells, the number of units, and the method of integration into the building.

5.3. Maintenance and Cleaning: Dirty surfaces and lack of care in cleaning them lead to a reduction in the efficiency of the surface to convert solar radiation to energy by up to 5%.

5.4. Temperature: Temperature deviation negatively affects temperature efficiency, which requires the presence of an air medium for cooling and its consideration in the installation details.

5.5. Orientation and Tilt: Proper orientation (preference to the south) and the appropriate degree of inclination (0-75 degrees) in the case of merging with roofs (75-90 degrees) in the case of merging with facades to increase the effectiveness of the cells by European guidelines IEC 63092-1

5.6. Shading: Exposure of the PV system to shading due to problems in the design of selected BIPV products, or the architect choosing the wrong placement to integrate PV into the building in such a way that the system is exposed to shadowing by landscape elements, or structural details of the building, negatively affects the efficiency of the system in converting solar radiation into energy.

5.7. Quality of system components: Lack of attention to the components of the photovoltaic system, such as the inverter, may reduce the efficiency of the system by 8%, which is a percentage that exceeds the permissible limit (less than 5%).

6. RESIDENTIAL BUILDING INTEGRATED PV

This part displays practical examples of residential buildings seamlessly integrating photovoltaic cells, these applications showcase the profound impact of such integration on sustainable energy production and environmental responsibility. The diversity of applications was considered in the selected projects.

6.1. Eglon House, North London, UK.

A Skylight glass roof was made, consisting of 13 units of photovoltaic glass made of amorphous silicon with a low degree of transparency, covering an area of 45 square meters Fig 14, achieving good insulation against external factors, and achieving natural lighting, preventing the leakage of ultraviolet and infrared rays from passing into the space. This application helps It generates energy estimated at 53,077 kWh, helping to operate 104 lighting units for 4 hours a day, in addition to reducing carbon emissions (36 tons) over 35 years.[31]

6.2. Private House, Nablus, Palestine.

A canopy was of crystalline silicon glass with monocrystalline solar cells covering an area of 76 square meters Fig 15, this application helps generate energy estimated at 290,180 kWh, helping to operate 570 lighting units for 4 hours a day, in addition to reducing carbon emissions (194 tons) over 35 years [32].

Fig.14. PV Skylight of Eglon House

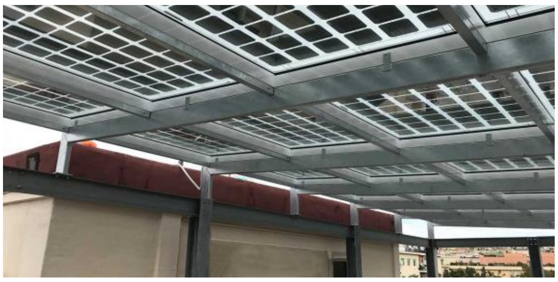


Fig.15. PV canopy of Private House in Nablus

6.3. Social Housing Building, Berlin, Germany.

A building was constructed in 2000 AD, where 480 units of multi-layered safety glass were installed, including 72 polycrystalline solar cells, to cover an area equivalent to 428 square meters on the southern facade of the building, Fig16. This application resulted in an annual energy production equivalent to 25,000 kWh, covering part of the electricity demand for elevators, ventilation, and emergency lighting. And others in the building. In addition, the solar energy installation is connected to a public network to transfer surplus electricity, and the application also contributes to reducing carbon emissions (75 tons annually) [33].

6.4. Multi-Family Housing, Athena, Greece.

A building was constructed in 2002 AD, double skin facades were installed, where the outer shell installed on the building's southern facade is made up of different sizes for 480 units of polycrystalline photovoltaic panels covering an area of 426 square meters, Fig 17. This application resulted in an annual energy production equivalent to 25,000 kWh and a reduction in Carbon emissions (75 tons annually) [33].

6.5. Residential Building, Monstera, Italy.

A four-story building used 217 units of monocrystalline silicon photovoltaic cells installed as PV Parapets Fig18, the total area of PV Parapets is 228 square meters with three different sizes and a 4T+4T glass configuration. With a degree of transparency of photovoltaic glass of 43%, this application helps generate energy estimated at 692,693 kWh, helping to operate 1,359 lighting units for 4 hours a day, in addition to reducing carbon emissions (464 tons) over 35 years.[34]

Fig.16.Social Housing (PV Glass)

Fig.17. Multi-family building(Double skin Facade)

Fig.18. Residential Building (PV Parapet)

6.6. Private Villa, Giza, Egypt

One of the villas at the Al Rabwa residential Compound in Sheikh Zayed City, Giza relies on solar energy to provide its Energy needs, through the installation of Polycrystalline PV panels (on a grid system) on its sloped roof without Bulk structure Fig.19, this application generates energy estimated 10KWh, and contribute to decreasing Electricity bill with average 2000L.E/Monthly [35].

Fig.19.Private Villa (PV full roof solution)

7. SWOT ANALYSIS OF BIPV APPLICATIONS IN RESIDENTIAL BUILDINGS IN EGYPT.

This section of the analytical study aims to elucidate various aspects related to Building Integrated Photovoltaic applications within residential buildings in Egypt, these insights will be summarized in Table 1 for a comprehensive overview.

Table 1. SWOT analysis of BIPV application in Residential buildings in Egypt [by Researcher]

▪ *Strengths*
-Solar Radiation during the year -Egyptian Sustainable Vision 2030AD and its importance rely on clean renewable sources of Energy - Government approval to purchase surplus electricity from customers. - Previous success in application in global residential buildings. - Residents' desire to enhance economic income and reduce electricity bills. - Avoid damage to electrical appliances because of the electrical load reduction policy.
▪ *Weak Points*
- Neglecting professional assistance in designing and installing the BIPV system. -Neglecting Maintenance Despite the importance of periodic maintenance to clean cells from dust in Egypt - Accidentally subjecting the system to shading. - Purchase and installation costs may be expensive for most Egyptian families. - The lack of availability of all BIPV products (High Quality) in the Egyptian market due to obstacles in importing
▪ *Opportunities*
- Rationalizing spending of hard currency to import fossil fuels. - Reducing the costs of combating air pollution in Egyptian cities. - Support Public Health by decreasing Carbon Emissions - Increasing investments in the PV industry and opening export opportunities. - Providing job opportunities for young people to work in new factories to produce BIPV products. - Increase in foreign exchange as a result of exporting BIPV products.
▪ Threats
- Applied BIPV system vulnerable to theft or acts of vandalism. - The state does not purchase surplus electricity from the population at remunerative prices. - The lack of investors or entities that support low-income residents in bearing part of the purchase and installation costs. - Lack of awareness among most residents of the importance of relying on renewable energy as an energy source.

Based on the previous SWOT analysis, the state's trend toward encouraging the population to BIPV applications has an economic return on the state and individuals. This value is reinforced by a feasibility study for one of the companies on implementing BIPV applications in Cairo for example, this feasibility study confirms the effectiveness of cell applications in generating energy and reducing carbon emissions specially roof-integrated PV such as Skylight, Canopy, and PV Pavers for Rooftop, the researcher summarized the findings of this study in the following table 2.

Table 2. Summary of Feasibility Studies of some BIPV applications, case study Cairo [36] extracted by Researcher

Cairo	**Double Skin**		**Curtain Wall**		**Skylight**		**PV Pavers**		**Balustrade**		**Canopy**	
	A-Si	C-Si	A-Si	C-Si	A-Si	C-Si	A-Si	C-Si	A-Si	C-Si	A-Si	C-Si
Peak Power Wp/ M^2	57.6	156	34	115	40	125	57.6	125	28	102	57.6	156
Electricity Generated kWh/ M2	1440	3819	850	2815	1897	5670	2528	5254	700	2497	2732	7077
CO2 voided. Kg/ M2	658	1745	389	1287	867	2591	1155	2401	320	1141	1248	3234

Note: PV cell type: AMORPHOUS SILICON (A-Si), No TRANSPARENT. CRYSTALLINE SILICON(C-Si) NO TRANSPARENT

However, the high cost of the selected BIPV applications compared to the traditional system based on fossil fuels represents a major obstacle to expanding the use of BIPV applications in residential buildings. It requires significant support from the state and investors to supply the local market with BIPV products (high quality + low cost) to encourage citizens in Egypt. Installing BIPV in their residential units and collecting donations to rehabilitate housing in poor and middle-class areas to become energy producers may be one of the solutions proposed by the researcher, Also, the importance of raising awareness of climate issues and the importance of renewable energy, in addition to training the population and providing financial support and advice, is important for the success of BIPV in Residential Sectors.

8. RESEARCH RESULTS

8.1. Theoretical study results:

- The application of the BIPV system in residential buildings is of great importance to Egypt, as the residential building sector consumes the largest percentage, 41.4% of the total energy sold, and this will help rationalize the hard currency required to largely import fossil fuels and reduce the costs of combating pollution in cities.

- Photovoltaic cell technology Supported Architects variety of BIPV products that are easy to integrate into all building elements without bulk frames Like BAPV systems and convert solar radiation from a factor that negatively affects the comfort of users and the safety of the structure to a positive factor in providing the building's needs from a clean and renewable source.

- Success of Selected BIPV application required accurate calculations, quality of system components, avoiding shading, Correct orientation (South is the best), correct tilt (0-75 degrees for roofs, 75-90 degrees for facades), Attention to maintenance, and avoiding dust or any pollution.

8.2. Analytical Study

- Many residential buildings in the world that use one of the BIPV applications provide their clean energy needs and avoid large quantities of Carbon Emissions per year.
- According to Table 2, Egypt has an Ideal Environment for the Success of BIPV applications, and roof-integrated PV applications are better than facade-integrated PV applications where Electricity production And Carbon Emissions are avoided.
- The problem of maintenance and the high costs of BIPV applications represent the most influential factors in the failure of the application, which requires awareness of the importance of maintenance and how to apply it, and the importance of working to reduce the costs of BIPV products and provide it at affordable prices for all.

9. RECOMMENDATIONS FOR AUTHORITIES.

9.1. For Local Authorities.

- Spreading awareness among members of Society about the importance of Renewable Energy, such as Solar Energy, in providing clean Energy and enhancing economic income through various media outlets and social media pages, and holding scientific seminars on this matter in all state institutions
- The state must provide facilities and incentives to Residents to qualify existing homes to rely on the BIPV system and pledge to purchase surplus electricity at remunerative prices.
- Developing laws and legislation that contribute to expanding Residential Building Integrated PV on a large scale in Housing projects and encouraging community members to apply it in their own homes.

9.2. For Architect

- Integrating the architectural design of Residential buildings and renewable energy applications, such as choosing BIPV applications appropriate for the target building to provide the building's energy needs and convincing the client of the importance of this step on his economic income and Health.
- Aware of the Updates in BIPV technology and working to improve the efficiency of Energy consumption within buildings in a sustainable approach.

9.3. For Investors and charitable organizations.

- Bearing the energy costs in the buildings of individuals with limited income in society and compensating for this support by selling surplus production or free advertising to those institutions.
- Investing in photovoltaic technology and working to provide products of high quality and affordable prices.

9.4. For Residential Developers.

- Considering the reliance on renewable energy sources in the design process, especially the photovoltaic system integrated into buildings and site landscaping elements.
- Paying attention to maintenance work for the photovoltaic system integrated into the building to maintain the system's efficiency in producing Electricity.

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