Impact of Solar Energy on Urban Design
(Case Study, Benban΄s PV Solar Park)

Abstract:

At present, about 50 % of the world's population lives in cities and by 2050 this number will rise to 68 % (UN; 2014). Cities consume more than two-thirds of the world's primary energy and emit more than 70 % of the world's greenhouse gases. As a major energy consumer, the buildings sector accounts for 28 % of global total carbon emissions and this proportion will continue to grow especially in developing countries. The rapid urbanization has placed a heavy burden on the environment and energy, which means that effective measures must be taken to meet the growing urban energy demand. Reducing building energy consumption and increasing the use of renewable energy is considered to be one of the most effective means to meet the current energy challenges, and this view has become the consensus of policymakers and researchers .In recent years, solar energy has gained popularity as a renewable energy source, and its incorporation into building design has emerged as a crucial element in creating sustainable and energy-efficient constructions and decreasing in greenhouse gas emissions and the total carbon footprint of a building structure .The use of solar energy into architectural design can help create healthier interior environments for building inhabitants, aids in lowering indoor air pollution and enhancing overall indoor air quality by lessening the requirement for conventional energy sources like coal and natural gas. In addition a building may generate its own electricity by adding solar panels, which eliminates the need to buy energy from the grid. Over time, this reduces energy costs and generates a return on investment. One of the most promising renewable energy technologies is photovoltaic (PV) which is a truly elegant means of producing electricity on site, directly from the sun, without concern for energy supply or environmental harm, make electricity out of sunlight, silently with no maintenance, no pollution, and no depletion of materials. Alongside wind energy, solar PV would lead the way in the transformation of the global electricity sector. Cumulative installed capacity of solar PV would rise to 8 519 GW by 2050 becoming the second prominent source (after wind) by 2050. Moreover a Building Integrated Photovoltaic (BIPV) system consists of integrating photovoltaic modules into the building envelope, such as the roof or the façade. By simultaneously serving as building envelope material and power generator, BIPV systems can provide savings in materials and electricity costs, reduce use of fossil fuels and emission of ozone depleting gases, and add architectural interest to the building. The research study investigated how critical factors such as latitude and

season; size, dimensions, orientation; roof specifications, local climate and other characteristics of the installation site of Photovoltaic Cells could affect the amount of solar energy absorbed which in turn could affect the feasibility and performance of the solar panel. So, the aim of this study is to assess the impact of photovoltaic application on the urban landscape like Benban Village in Aswan to mobilize private investment to help building the world's largest solar PV power plants as well as stimulating economic growth, creating direct and indirect jobs in the project construction phase, reducing harmful emissions by feeding homes with clean energy, and launching more mega projects across the country for a new Egypt by proposing an integrated spatial plan for a benban's PV solar park complex(Grand Benban) .This is achieved through introducing various application levels of PV on surface facades on Benban park in Aswan. Such projects also aimed to establish giant projects all over the country for a better future for Egypt. The results had shown that environmental harmony, power generation, innovative design, installation height and technique and social benefits of PV system are the main impacts of the PV system on urban landscape and Aswan will be the cornerstone of the field of solar energy over the world in the future. In conclusion, this research guides the focus of urban and town planning and design on the application of solar energy and its impact on economy and recommends the future research directions on solar urban planning .

Research Objectives:

This study investigates the impacts of design configurations including positions, dimensions, and orientations, areas of PV and movement options to track the sun on increasing the amount of generated renewable energy. This is achieved through introducing various application levels of PV on building facades. The projects being implemented on the Benban land in Aswan to encourage private investment to build the world's largest solar PV power plants, as well as stimulate economic growth, creating direct and indirect jobs in the project construction phase, reducing harmful emissions by feeding homes with clean energy.

Research problem:

The increase of energy needs and its impacts on global warming and energy prices made it imperative to utilize various renewable energy sources including PV and BIPVs.

Research Hypothesis:

Due to the energy crisis and global warming, carbon emissions have gained increasing attention in recent years. One of the major causes of carbon emissions is from building industry as it is responsible for half of the world's energy consumption. It is necessary to meet the significant energy demand of cities by adopting strategies for the optimal use of local, clean and abundant energy sources to achieve energy sustainability. The institutional integration and the institutional social cohesion of the solar energy

institutions in Benban contribute to shaping the geo-economic structure of the region.Solar energy for-profit and non-profit organizations will play a clear role in the local and regional development of Benban.

Research Importance:

The urgent needs to reduce fossil fuels and achieve energy consumption balance led to search for strategies to adopt renewable energy systems to reach near zero-energy buildings, including the use of photovoltaic cells (PV). The present research investigated how application of PV could help improve thermal performance and energy consumption through controlled interactions with direct sunrays and solar gains and its impact upon economy

Introduction:

The global installed capacity of solar PV would rise six-fold by

2030 (2840 GW) and reach (8 519 GW) by 2050 compared to installations in 2018 (480 GW). Solar PV installation costs would decline dramatically from now to 2050. Solar PV would be one of the cheapest generating sources,(IRENA, 2019a).

People used solar energy in their homes from very ancient times, they kept using passive solar architecture principles in the design and construction of their buildings until the industrial revolution. The energy crisis in 1970's showed that fossil energy resources are limited and also they give harm to the environment. Therefore, new and renewable energy resources have begun to be searched **(Fraunhofer ISE** (2019)). (One of the first uses of PV panels in building design was a multi-story building in Boston in 1978 with PV panels on the roof. The second application was the Carlisle House with a 7,5 kW power system net connected and constructed in 1980, It has passive solar heating and cooling, super-insulation, thermal mass for energy storage, day lighting and a roof integrated solar thermal system [2).

Another example of Building Integrated Photovoltaic (BIPV) use is the "Impact 2000 House" in Brooklyn, USA which was constructed in 1984, it has a roof with

PV panels composed of12 PV modules on 40 m2 area , 45^0 incline and 4,3 kW power that produces most of the energy demand of the house)(2).
Reducing energy related CO_2 emissions is at the heart of the energy transformation. Rapidly shifting the world away from the consumption of fossil fuels that cause climate change and towards cleaner renewable forms of energy is critical if the world try to reach the climate goals agreed in Paris (IRENA, 2019a) . There are many drivers behind this transformation, first the rapid decline in renewable energy cost since 2018 , second air quality improvements and thirdly, reduction of emission carbon,(IRENA, 2019a). Finally, transforming the global energy system would also bring significant socioeconomic benefits which are crucial to influencing any political decision (IRENA, 2019a; IRENA, 2019b), (*UN Population, 2018* (Figure 1). The share of buildings in energy increases in developing countries than in developed countries, this makes it necessary to research sustainable energy economics compatible with the environment as the way towards energy supply and at the same time achieve future economies appropriately **(IRENA, 2019b)** .

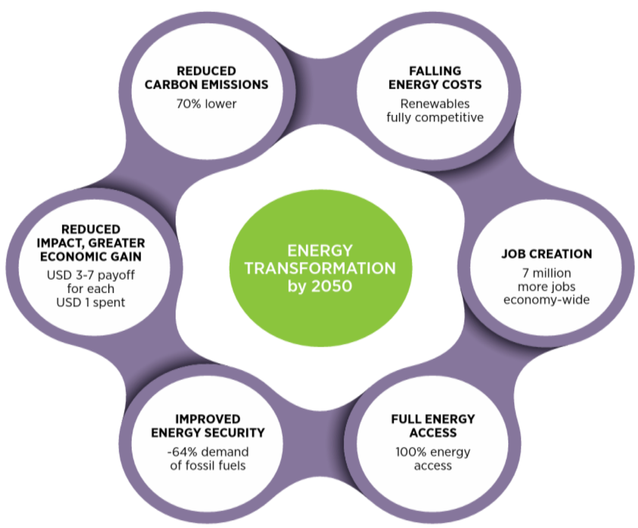


Figure 1: Pressing needs and attractive opportunities are driving the ongoing energy transformation The key drivers for energy transformation presented in this figure is based on IRENA's REmap Case by 2050 compared to current levels. Source: (IRENA, 2019b)

Starting from 2020, it is expected that the cost of obtaining renewable energy especially generated from the concentration of sunlight less than that of traditional sources (2), (North Africa and Middle East region (MENA Region) as a result of continuous research and development and the expected expansion in the use of these technologies in all activities, Figure(2,3,4) (Weiss, W. and M. Spörk-Dür (2019).

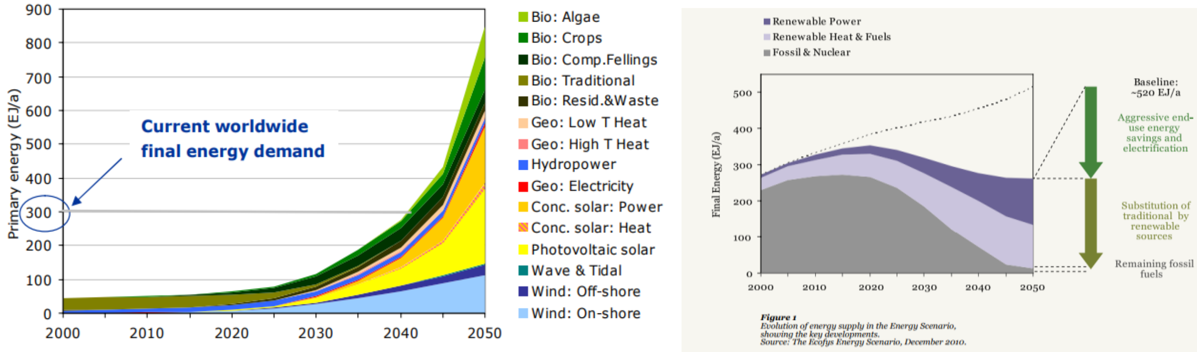
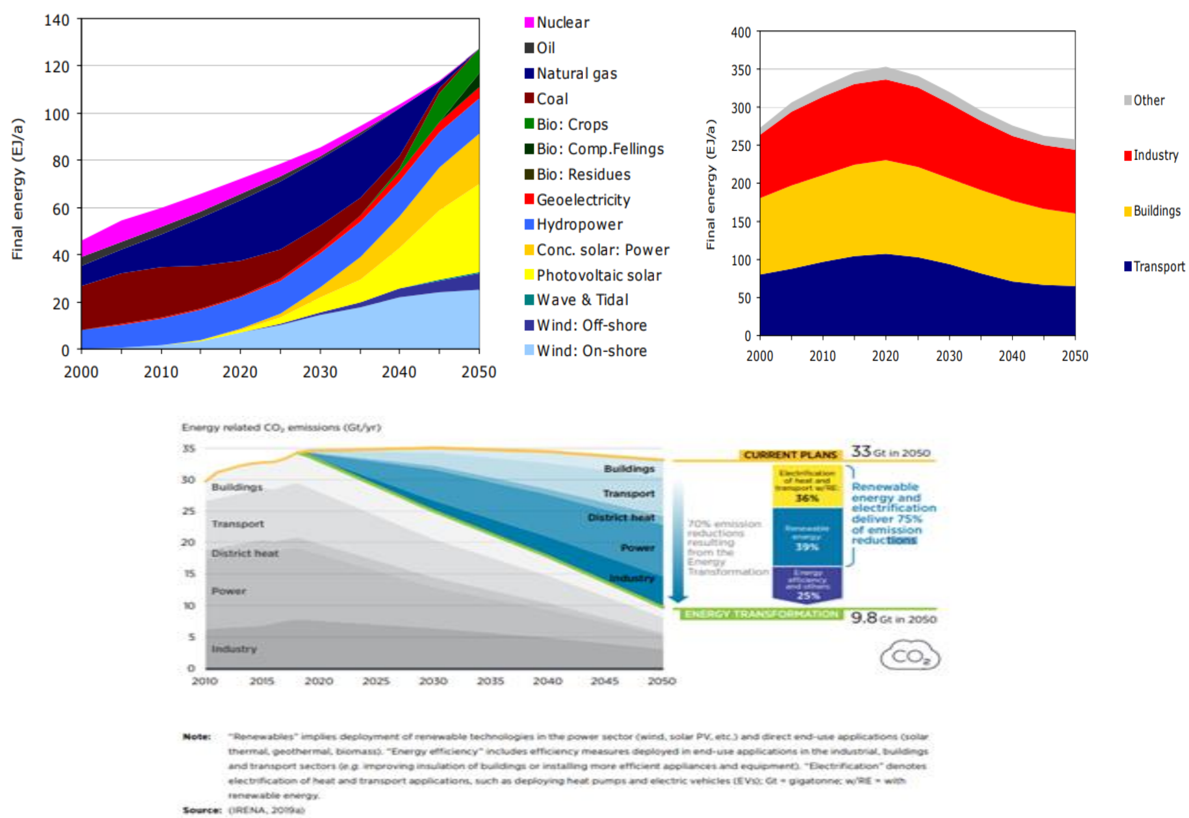


Figure (2) Global deployment potential of various renewable energy sources



Figure(3) Global power supply in the Energy Scenario.

Global energy demand across all sectors, from 2000 to 2050.

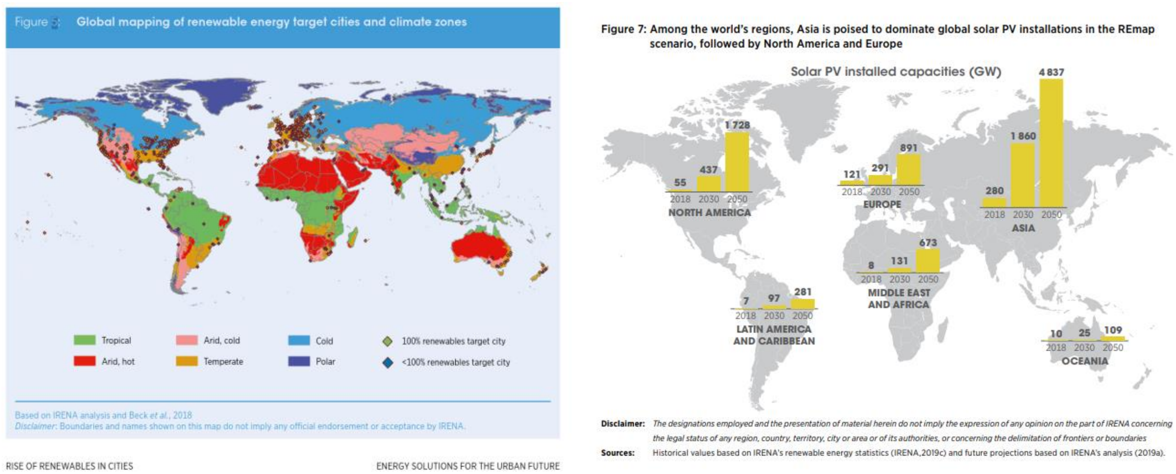


Figure (4): Weiss, W. and M. Spörk-Dür (2019), Solar heat worldwide: Global market development and trends in 2019, International Energy Agency Solar Heating & Cooling Programme, Paris, www.iea-shc.org/Data/ Sites/1/publications/Solar-Heat-Worldwide-2020.pdf.

Solar urban planning is emerging as a more specific concept that promises to provide city planners with the tools and techniques needed to design low carbon cities through solar integration in the built environment. The PV UP-SCALE project was an initiative by the European Union in 2006, **aiming** to draw urban planners' and city managers' attention to the various economic and technical tailbacks regarding solar PV in the urban planning process (*IRENA* ,2020). Solar design can take many different forms across disciplines with different methodologies and goals, ranging from acquiring architectural visual effects to assess illumination for day lighting and solar radiation potential on building surfaces for PV implementation, Figure (5), (Hatti M. ,2019).

Figure (5) Carlisle House **Impact 2000 House** (www.solardesign.com, retrieved on 24.01.2013)

Furthermore, a capability of solar design methodologies and tools to accurately and time efficiently simulate light phenomena can greatly influence performance results and design decisions. This is especially important in complex cases such as dense urban settings with the significant surface shadowing, and vertical facades including day lighting devices and photovoltaic. Consequently, choosing a suitable approach and tool for each design phase is essential for achieving unique design and performance goals. It is estimated that 80% of the energy a building used in its lifecycle is consumed during the operational stage, while 20% is consumed during the construction stage including their raw material extraction, construction and demolition [1,2] .An increasing number of architects and builders are looking into using renewable energy sources in their projects due to concerns over energy efficiency and sustainability, figure(6).

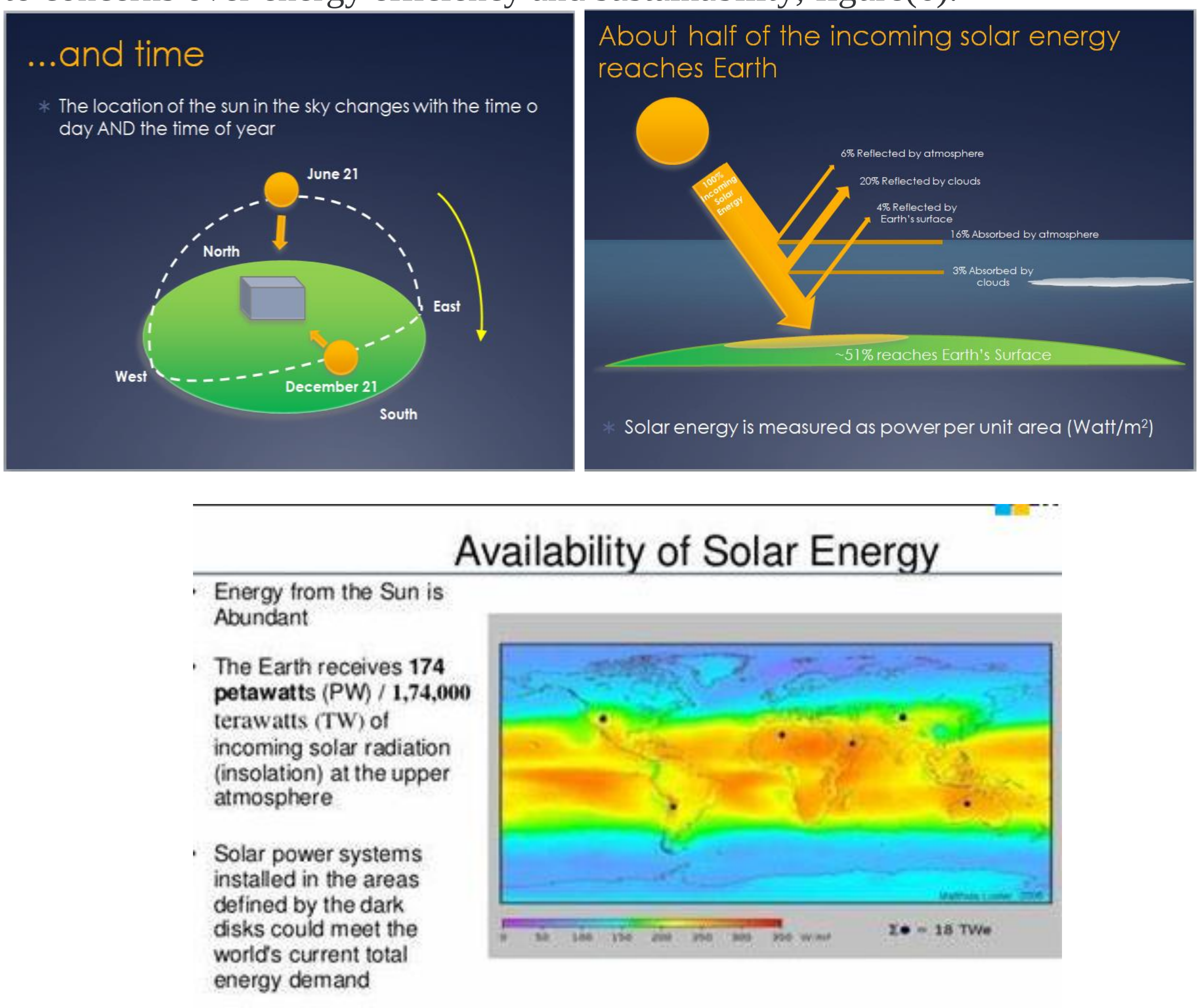


Figure (6) Availability of solar energy all over the world (Solar radiation: ~1 kW/m2 Sunny hours per year: 1750-2250 hours/year Energy: 1175-1325 kWh/m2 /year), IRENA (2021)

Solar urban planning can be more broadly defined as a socio-technical and political process that seeks to maximize solar energy potentials in urban areas by integrating solar energy considerations into all stages of the urban planning/design process to achieve sustainable energy solutions and long-term environmental sustainability, (IRENA (2019d) .

A Planning process phases for solar buildings in urban environment:

The urban environments in solar urban planning are divided into: existing urban areas, new urban areas and solar landscapes .Large scale solar farms may be built in the immediate surroundings of cities characterized by natural landscapes as Benban solar power plant in our study , and other places such as car parks, university campuses, commercial and industrial areas within cities could serve as avenues for large scale PV installations ,(IREN, (2019a), (figure 7).

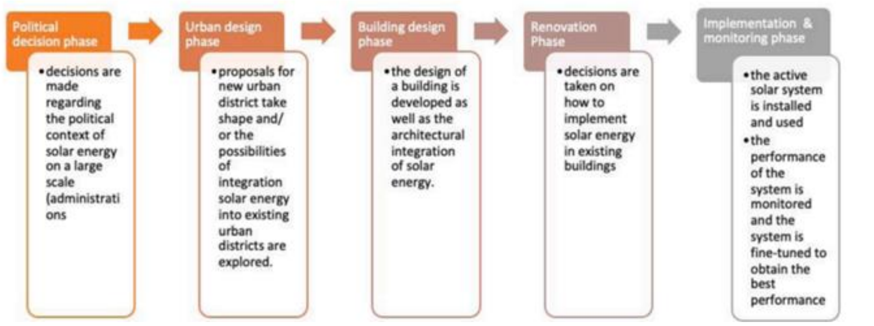


Figure (7)A Planning process phases for solar buildings in urban environment: Kanters & Wall, 2018

How to Design& Install a Solar PV System:

A-PV System Component Basic Descriptions:

1-PV Modules/Panels

PV modules are clusters of solar cells that convert sunlight into direct current (DC) electricity. Since PV systems do not produce emissions, they are a clean and environmentally-friendly way to generate electricity. There are many factors to consider when choosing the right PV module/panel, including power output, efficiency, cost, warranty, and aesthetics. The type of PV module/panel selected can significantly impact a building's energy performance and, ultimately, its rating. The composition of solar panels depends on the type of panel used. Silicon-based (c-Si) PV technology (including mono-crystalline, poly and multi-crystalline, ribbon and amorphous silicon) currently dominates the market, with a market share of about 92% (IRENA and IEA-PVPS, 2016). Most of the companies, in Benban, using Poly Crystalline PV panel type, due to its low cost; high efficiency; suitable temperature characteristics; good life time; safe environmental consideration, low effect of shade, and required 4-5 acres Land/per MW (16187 – 20234 m2 /MW).

2-Mounting Systems (Racking):

Racking systems are the framework that PV modules are attached to. There are many different racking systems available. Racking provides structural support for the module, keeping it in place even in inclement weather. It also helps to ensure that the module is positioned at the correct angle to maximize its exposure to sunlight. There are two main types of systems – attached and ballasted. Attached systems are fastened directly to the roof structure, while ballasted systems rely on weights to keep them in place. Building type, roof type, budget, and aesthetics play a role in the decision-making process.

3- **Inverters**

Solar power systems typically consist of panels that convert sunlight into electricity, and inverters that convert that electricity into a usable form. They are typically mounted on a pole or rack near the array and come in various sizes and configurations. Two main types of inverters, micro-inverters and string inverters, are on the market. String inverters are the more traditional type of inverter and are often used in large-scale solar power systems. Micro-inverters offer several advantages over string inverters, including more granular monitoring capabilities, maximize the power output of each individual PV module , enhanced safety, longer warranties, greater flexibility ,easier installation, and operating independently since they are typically integrated into the panel itself. This can be beneficial when shading or other factors reduce the production of one or more modules in a string inverter system (https://schnackel.com/blogs/solar-photovoltaic-pv-system-design-basics)

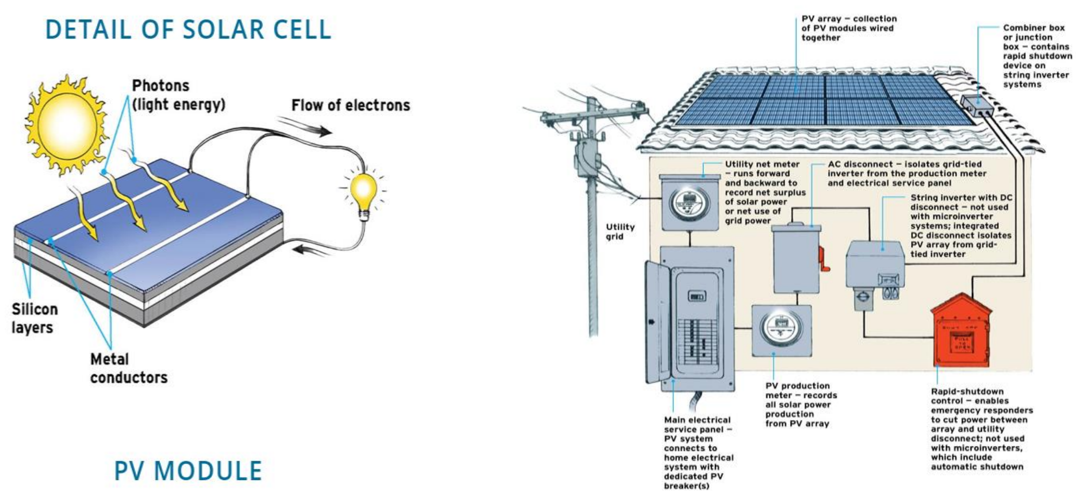


Figure (8) PV Cell unit & Grid-tied PV systems connected to the utility grid

source: Green,M.A. (2019)

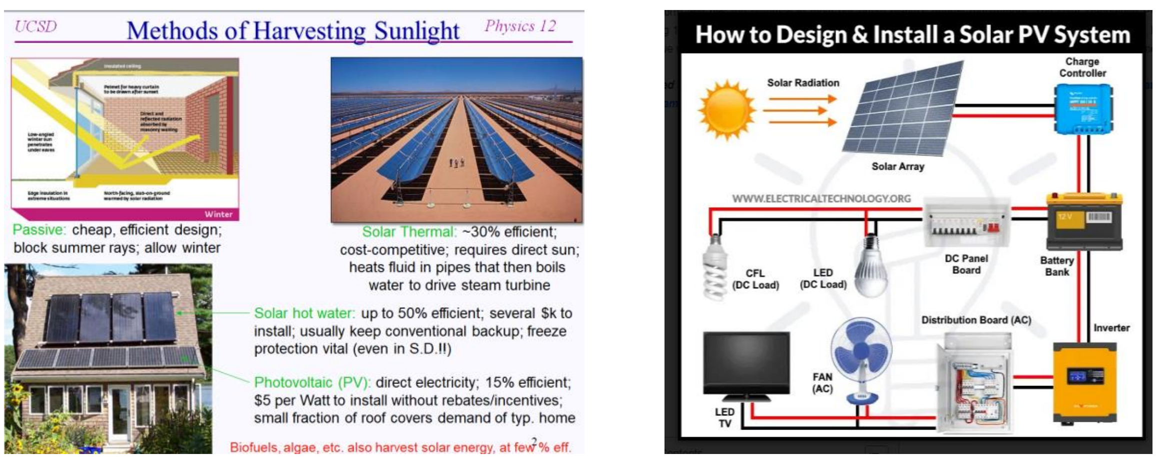
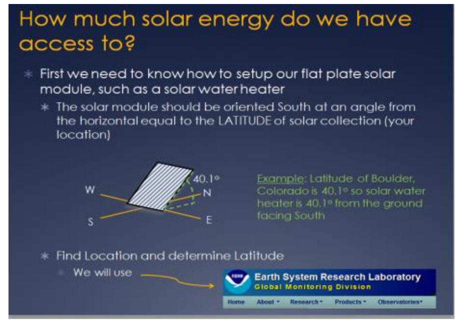


Figure (9):Methods of Harvesting Solar Energy& Design of Solar PV System source: Green,M.A. (2019)

B-Building-integrated photovoltaic (BIPV): The photovoltaic panels act as both a functional and aesthetic component of the building, and freestanding systems. They can be adapted to a variety of surfaces (*e.g.* roofs, windows, walls) as an integrated solution, providing both passive and active functions(4). Other functions, also unique to BIPV systems, include the possibility of real-time thermal or lighting regulation (Solar PowerEurope,2019b). BIPV systems often have lower overall costs than PV systems requiring separate, dedicated, mounting systems, (figure10),(Jakica, N. 2018).



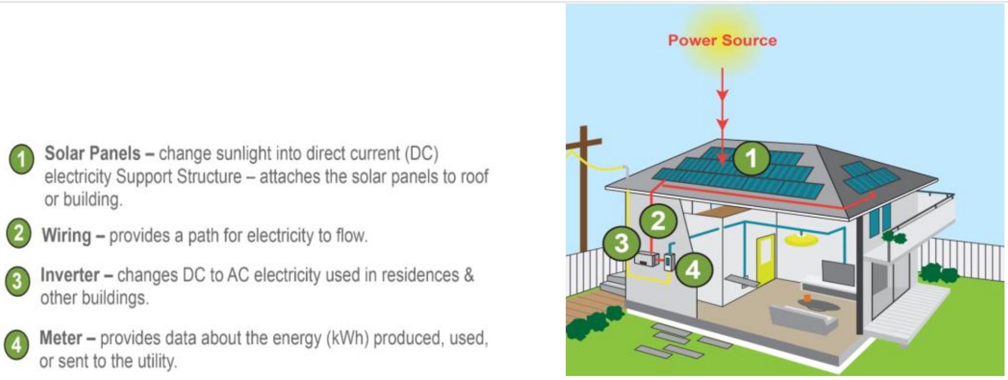


Figure (10): Benban solar power plant &Building-integrated photovoltaic (BIPV)

(by Steven Strong,Solar Design Associates, 19-2016)

C-Orientation & Positioning of Solar Module:

Solar modules have to face the Sun at all times of the year in order to maximize energy yield. Solar plant engineers achieve this by facing the modules towards the South in the northern hemisphere and towards the north in the Southern hemisphere. This is generally referred to as the 'tilt' of the solar system. Correct orientation and positioning assures that solar modules get access to the sun throughout the day. Sun stays comparatively lower in the sky in the winters than summer months; therefore, in these months orientation of solar panels has to be more vertical, as solar rays will have to pass through more atmospheres to reach the panels. However, in summer months, the sun stays much higher in the sky; therefore, it has to travel less distance to reach earth's surface. So, horizontal orientation of solar modules can easily work efficiently in harvesting solar energy in these seasons. The Sun follows a different path through the sky during winter than in summer as we move away from the equator. So, in order to capture as much energy as possible from the Sun throughout the year, solar modules need to be tilted by an angle of ±5° or ±10° (depending on latitude) 3 or 4 times a year. This is called seasonal tracking, (figure 11),(**Zeeshan Hyder,2023).**

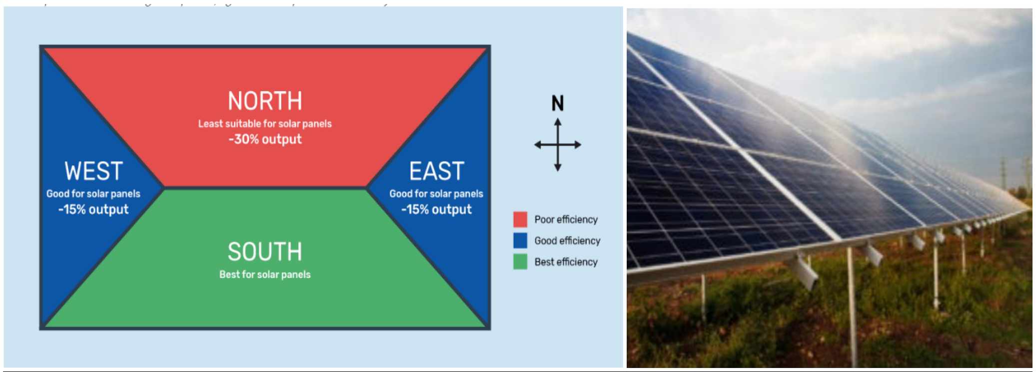


Figure (11):South is the best direction for solar panels to face overall (https://www.solarreviews.com/blog/best-direction-orientation-solar-panels) Zeeshan Hyder"What is the best direction for solar panels to face?", 10/09/2023

D-Zoning Laws and Permitting Requirements

Zoning laws and permitting requirements may impact on-site solar development and should be taken into account during the building planning phases. Applicable solar access laws and historic preservation regulations should be evaluated as well. (**Akshay VR**, 2023).

Case Study:

The solar energy is the most important source of energy on the globe. Egypt geographically lies between latitudes 22 and 31.5 north, so Egypt is at the heart of the global solar belt, and thus it is one of the richest world countries in solar energy In the village of Benban in Aswan, the largest solar energy station in the world is built, where 90% of the energy produced from the High Dam will be generated This is within the framework of the strategy developed by the New and Renewable Energy Authority, which aims to make 20% of the electricity produced in Egypt of clean energy by 2022 ,(NREA, (2018).

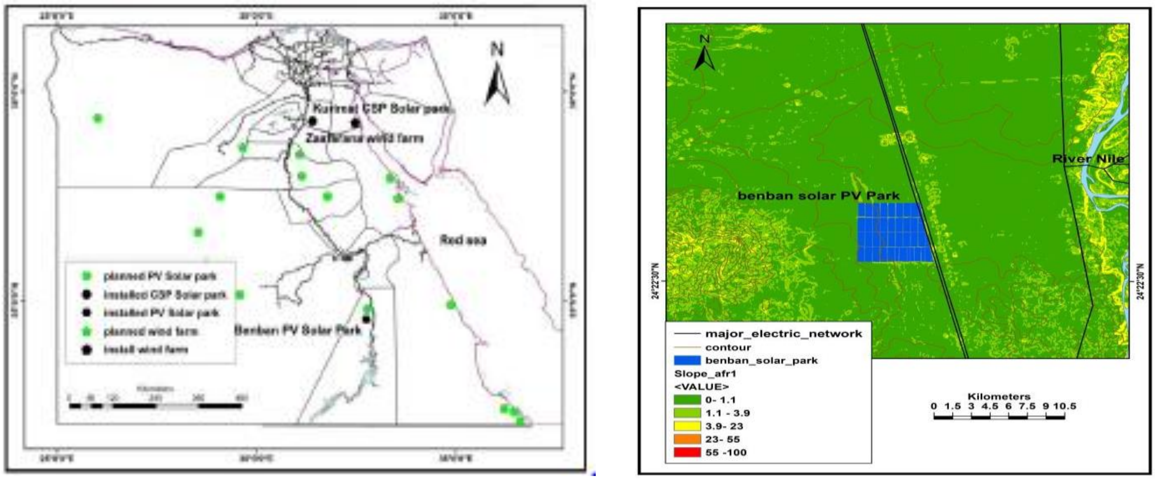


Figure.12 Renewable Energy projects sites in Egypt until, 2035 including Benban park
Source: author based on New & Renewable Energy Authority, 2019,

In the land of gold, near Aswan lies one of the largest solar parks in the world the Benban park which extends over an area of 37 square kilometers near the “desert road” between Aswan and Cairo in the village of Benban in the Daraw Center(3). The Benban park designed to produce an additional 2000 megawatts of electricity for the unified national grid . Work on the project began in 2015 in accordance with Presidential Decree No. 274 of 2014 and the project is located on an area of 9,000 acres on the desert road "Aswan - Cairo", and of such a huge size that it can be monitored from space, including seven million solar panels at a cost of about four billion dollars, and the project is implemented by about 40 companies specialized in solar energy and the investment cost of the project is about 3.4 billion euros and the implementing companies have completed 90% of the four main transformer stations (Benban (1,2,3,4)) to discharge the energy produced from the solar stations. The solar energy project in the Benban area of Aswan Governorate is the largest new and renewable clean energy project in the Middle East, and has been able to win many international awards, the latest of which is the Arab Award "Government Excellence", due to the importance of this project in the production of clean energy The production of the project is equivalent to the energy produced by the High Dam estimated at about 2100 megawatts, and the solar energy project can be described as a "new high dam" on the land of Aswan(8). Benban is now one of the largest solar parks in the world, with seven millions of photovoltaic panels, providing electricity to more than one million homes. The African Development Bank supported the solar park with $55 million(3).The park includes 34 solar power plants, each with a capacity of 50 megawatts. At full capacity, it will produce 3.8 terawatt hours of electricity annually(8). The project created at least 20,000 jobs during the construction period, with an additional 6,000 permanent positions by the companies operating the park. There are also plans by the local authorities of Aswan to transform the Benban Industrial High School into a solar energy school that will provide training on the various aspects of solar energy and electromechanical engineering. The Benban solar park could become a model of clean energy production in Africa as the continent strives to achieve the UN strategy in the framework of the Sustainable Development Goals(3).

Figure(13) Benban", the Largest Solar Power Plant in Aswan
https://www.afdb.org/en/success-stories/egypt-benban-model-clean-energy-production-africa-60169,2023

Project Objectives

1 . The project is a new nucleus for generating electricity in Egypt from the sun and supporting the national network, the site of the project was selected in the area of "Benban" in Aswan, based on the studies and reports of NASA(7).
2 . The site includes 40 solar power plants under construction, the capacity of each station is 50 mw, total energy generated by the sun is equivalent to 90% of the electric power generated by the High Dam.
3 . The Gas Insulated Stations (GIS) will be constructed for the first time in Egypt.
4 . The 40 solar power plants will be developed on plots ranging from 0.3km² to 1.0km² in size. Each plant will be equipped with photovoltaic (PV) panels mounted on fixed, immovable frames, which will be laid in arrays. The PV panels will range in size from 1,200x600mm to 2,000mmx1,000 mm.
5 . The park alone reduces carbon emissions by two million tonnes per year

Climatic Advantages in Egypt:

-Most of the country, from Cairo to the Far South, receives radiation of more than 6 kWh/m2/day. The days when the clouds appear daytime hours are less than 20 days a year, and the total radiation from the north to the south increases till it reaches 5 kWh/m2/day near the North Coast and exceeds 7 kWh/m2/day in the far

south of Egypt (3).
- Most parts of the country, from Cairo to the far south, receive direct sunlight of more than 7 kWh/m2/day while the sun shines for over 4000 hours per year. Such numbers are among the highest rates in the world, figure (14).
- The southern desert in Egypt enjoys from 9-11 hours of sunshine per day, exceeding 3600 hours per year in various parts of Egypt.

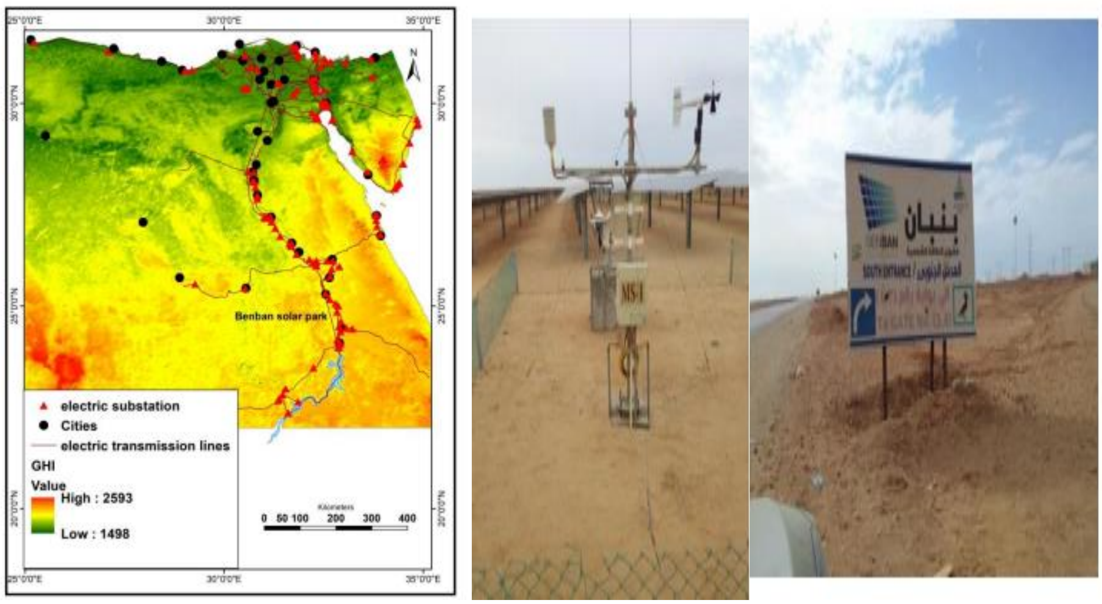


Figure 14:Global horizontal irradiation in Egypt, 2017(kwh/m2)-Benban solar PV park, meteological station, source: Kereush, D. & Perovych, I., (2017).

Strategic importance of the project:

Egypt is witnessing significant shifts in its quest to address the energy crisis it has been facing for years, by increasing the share of renewable energy sources to 20% of the electricity produced by 2022 and 42% by 2035. The developers believe that Benban's exceptional solar radiation levels, and low maintenance costs limited to cleaning photovoltaic panels from sand, enhance the feasibility of this project. Aswan is seen as the future of the south according to the development studies of southern Egypt, and is expected to achieve the highest rate of economic growth in the south, and is expected to account for the largest share of the population attraction in the development plan of southern Egypt as it is not repellent of the population and is a promising development resource to a degree that allows to absorb about a million additional people (7).

Economic return of the project:

The plant is the first step to exploit the sun on Egyptian territory to generate electricity and then transfer it to Europe through the ongoing link between Egypt, Cyprus and Greece, and the project will also allow Egypt to export energy abroad both to the African continent and to a number of Arab countries. It provides clean energy to hundreds of thousands of households, and helps Egypt reach its goal of generating 20% of the electricity used from renewable sources by 2022, according to a report by the African Development Bank (7). The project contributed to the creation of 11,720 direct jobs, 23,440 indirect jobs in the implementation period, and 6,000 after operation and 10% of the profits of the participating companies were allocated to social responsibility. The project contributed to avoiding 2 million tons of carbon dioxide emissions, promoting and attracting foreign investments in the region and issuing laws supporting investment, and the project also had a developmental and societal impact in the region by transforming the secondary school of industry into a school of solar energy(8).Aswan is now preparing to export it to the State of Sudan within the framework of the interest in transforming Egypt into a regional energy center through the project of the electrical interconnection line between the Toshka transformer station and Wadi Halfa with a length of 100 Kilometer (3)

Benban Solar Park Description (Project Study): Spatial characteristics of benban's solar park

1-The Government of Egypt has provided 37.2km² of land to NREA in Benban, in the town of Daraw Markaz of Upper Egypt, for the development of the Benban solar park. Benban's solar PV Park located in Aswan Governorate, 18km to the west bank of the Nile River and 43km to the north of Aswan, with an approximately 4 km from the paved Western Desert Highway Luxor-Aswan(7)

2- Benban's solar park is 4 km from the Upper Egypt Electricity Transmission Line, the Nag Hammadi High Dam line, with a length of 236 km and a voltage of 500(Egyptian Electricity transmission company,2020). The annual total solar radiation value of the region should be equal to or higher than 1620 KWh / m2 year. The total value of solar radiation ranges between 2472 kWh per m2 in Benban and 2439 kWh per m2 in Fares(8).

3-The increase in the average temperature of the region causes a decrease in the efficiency of the photovoltaic systems. Therefore, suitable temperature ranges between 15–40°C ((Kereush & Perovych, 2017, p.41)

4-The **slope** rate of 3% causes the cost increase, while 0% slopes cause water accumulation and drainage problems.The optimum slope rages between 5-15º (Kereush & Perovych, 2017, p.41). In benban region, the slope rate ranges between 0 to 1.1% and 1.1 to 3.9%

5-The 40 solar power plants will be developed on plots ranging from 0.3km² to 1.0km² in size. Each plant will be equipped with photovoltaic (PV) panels mounted on fixed, immovable frames, which will be laid in arrays. The PV panels will range in size from 1,200x600mm to 2,000mmx1,000 mm(3).

6-The amount of solar energy absorbed depends on factors such as latitude and season; size, dimensions, and orientation; local climate and other characteristics of the installation site; and the materials used in exterior walls and facades

7-Best Orientation and Angle of solar panel: The ideal angle for solar panels should be somewhere between 30° and 45°.The best roof orientation or direction of solar panels for people living in the Northern Hemisphere is south facing, the same is for people living in the Southern Hemisphere: it is best to install solar panels such that they face towards the north. Most direct sunlight exposure will be received on a solar panel system installed on a south-facing roof. The project lies approximately on latitudes˚24 26 ´and ˚24 27 ´north of the equator, ˚32 41 ´and ˚32 44 ´east of the Prime Meridian and is 0 m above Sea Level (environmental impact assessment of benban's PV solar power facility, 2016, p.7). Slightly pitched or flat roof shapes are considered best for installing solar panels

8-The arrays will be connected to inverters for converting the direct current (DC) power to alternating current (AC) power, which will be transferred by a transformer to the nearby power grid for distribution.

9-A control center will be constructed at the site, which will house the monitoring and communication equipment for the substations.

10-A 16km water supply pipeline from the Nile River is being laid to supply the water required for operations at the site.

11-To eliminate or at least minimize this risk, site selection should be made as far as possible to earthquake fault lines (Tunc, et al, 2019, p.1356). Egypt is divided into 5 seismic zones, and the project is located within zone 2.

12- The wide surfaces of the panels and reflectors used for energy production activities cause damage from the high speed winds. If the wind speed in the region exceeds 25-30 mps, (48- 58 knots) the system may be damaged. Therefore, the wind speed in the region ranges between 9.4 knots in March and 8.3 knots in December(13).

13-lighter colors roof of solar panels are good reflectors that aid in increasing the output of solar panels as well. On the contrary, darker shades are good absorbers and tend to decrease the efficiency of solar panels

14- Shade Hours**:** Solar panels are designed to work well even on a cloudy day. Therefore, an ideal roof for solar panels is one with ample sunlight but shaded only for a short portion of the day.

15-Design considerations for PV systems must include its use and electrical loads, its location and orientation, the appropriate site and safety codes, and the relevant utility issues and costs.(ESIA for Al Tawakol Photovoltaic Power Plant in Benban, 2016:65).

Discussion& Conclusion:

From the study ,it was found that, solar panel design considerations depends upon environmental and structural factors, both of which influence the economics, aesthetics and overall functionality of any solar system(7) .

Environmental Factors:

- Insolation - This refers to the average amount of solar radiation received, usually calculated in kWh/m^2/day. It is the most common way to describe the amount of solar resources in a particular area(7,8)
- Climate & weather conditions – High ambient temperatures can decrease the output of solar systems, and clouds and rainfall patterns can affect system output and maintenance requirements. High levels of air pollution can require regular cleaning to increase efficiency(7,8).
- Shading – Trees, nearby buildings and other structures can block the sun, reducing PV system output.
- Latitude – Distance from the equator affects the optimal tilt angle for solar panels to receive solar radiation(7,8).

Structural Factors

Solar panel requirements – The design of PV system should take into account whether the PV should be able to operate wholly independent of the electrical grid, which requires batteries or other on-site energy storage systems. Solar system design – The design of the PV system itself is determined by the buildings energy requirements, and any structural or aesthetic limitations that may limit material choices. Crystalline silicon panels have higher electricity outputs per square meter, but greater costs and design constraints. Thin-film

materials generate less electricity per square meter, but are less expensive and may be integrated more easily onto more surfaces (Marcin Frąckiewicz , 2023).
Solar energy has evolved rapidly after energy crisis in 1970's ,because with the crisis, it became clear that the fossil fuels are limited and they give harm to the environment so solar energy has been used in the design and construction of buildings(1). After a quick review of solar architecture, it can be seen that passive solar principles and active use of solar energy is developing each day. Architects use solar energy since the energy resource is up in the sky ready to be used and it is free(11). Therefore it can be said that buildings of the future will be solar architecture buildings, and architects of the future should be ready for that from today(13) .The installation of photovoltaic systems provides significant economic and environmental benefits, such as CO_2 and greenhouse gas reductions(1), in comparison to conventional energy production but photovoltaic systems are partially offset by negative impacts that cause restrictions to social acceptance [Marcheggiani ,2013]. Regarding Italian regions, particular geographical positioning of photovoltaic plants can cause significant differences in profitability and environmental impacts (Cucchiella,et.al,2015). Environmental damages such as agricultural land consumption and soil sealing are caused by the booming sprawl of solar modules in rural areas [Scognamiglio ,2016). Landscape impact is particularly critical for assessment, and subjective landscape perception should be considered to create a relationship between human perception and the environment. However, the researcher noted that landscape assessment of a new photovoltaic plant should be made with GIS spatial analyses and with other software tools and techniques (for example, picture analysis) (Tunc, A., et al, (2019).Satellite methodologies are more effective for the performance evaluation of medium and large photovoltaic plants, while visual Q sorting is more suitable for small photovoltaic applications in cities (Ming,et .al,2018). Incentive policies and ideal geographical location ensure an optimal use of solar energy in Europe [Dusonchet,et.al,2015], these methodologies are useful when assessing the landscape impact of photovoltaic applications. Recently, the application of photographs, interviews with the public, subjective feelings, and behaviors must be considered with a landscape assessment, which creates a connection between individuals and photovoltaic policy-making. By taking public preferences into account, planning of photovoltaic utilization and city planning will be performed with justice and integrity. Landscape assessments, together with social-psychological patterns from the public, are both indexes that can be used to evaluate the impact of a project. The impact of photovoltaic applications on landscapes must be considered during the project approval process(Ming,et .al,2018). Additional supportive measures on urban land use policy and energy policy should be made by the government and related authorities (for example, photovoltaic investors, building industry associations and companies) to

guide the installation of photovoltaic systems, including: (1) appropriate financial subsidy systems for different urban land use;(2) reduction of the cost of photovoltaic applications and increases in investment and technological innovation; and (3) a focus on public acceptance and psychological determinants to encourage the financing and installation of photovoltaic systems(IRENA, 2019b).

As regard case study the researcher found that :

- The future development of photovoltaic systems must be promoted by the government in the initial stages.
-The solar photovoltaic policy for different land use types will bring about significant improvements in the layout and design of photovoltaic applications in urban areas, so policy effects, which make the urban photovoltaic utilization a “top-down” system and increase social acceptance, should be considered.
-The study concluded that the most serious risks facing the project are the extreme high temperatures in the summer, which cause fires and damage equipment and cables, and rainfall in winter that stopped the plants.
-The spatial characteristics of Benban proved that it is one of the most suitable sites for the establishment of a solar energy complex in Egypt, according to the standards of the international literature.
- Most of the companies using Poly Crystalline PV panel type, due to its low cost; high efficiency; suitable temperature characteristics; good life time; safe environmental consideration, low effect of shade, and required 4-5 acres Land/per MW (16187 – 20234 m2 /MW)(13).
-The social embeddedness of Benban companies is still in the stage of evolution and formation; it may reach the stage of maturity, if the electronic industries and research & development become localized in Egypt
-The positive effects of the Benban project, is mainly represented in providing the national electricity network with about 4 TWh, employing about 20,000 workers in the various plants works, saving about 1,435 tons of carbon dioxide emissions and benefiting from social responsibility projects at the rate of one million pounds annual for each company in the villages of Banban Bahri,Qibli, Fares and Mansouriya(13).
- The project presented a proposal for the establishment of the Grand Benban Solar Energy Complex to remedy the weaknesses that appeared through the study of the institutional economic geography of the project.
-Based on IRENA’s RE map Case, the solar PV share of global power generation would reach 13% by 2030 and 25% by 2050.The breakthrough in renewables capacity additions over past few years has largely been achieved due to significant cost reductions driven by enabling government policies, including deployment

policies, research and development (R&D) funding, and other policies that have supported the development of the industry in leading countries (IRENA, 2019i).

Recommendation and Future search:

-Localizing the industries of components and parts for solar energy plants, such as solar panels, inverters, transformers and cables in Egypt. There are about sixteen sites of white silica sand in Egypt; the most important locations are Wadi QenaWadi El- Dakhl) and El- Maadi.

-Early monitoring of the weather and preparing a plan to quickly deal with climatic hazards such as torrential rains, high temperatures and dust storms.

-Soil stabilization around the Benban project to mitigate sandstorms in this dry area by using colloidal emulsions that increase soil resistance to erosion.

- Preparing flood drains and overflows in the event of dangerous floods, especially the area is located at the bottom of a mountain.

- Establishing technical schools specialized in solar energy to prepare and train technicians and solar energy research institutes to graduate engineers and developers.

-Applied co- location of wind and solar energy technologies that enable operators to sweat extract the most efficiency from grid connection assets, due to high wind speed and solar irradiation occur at the same time, as it was in Ireland.

-The expansion of passivated emitter and rear cell/contact (PERC) technology, offers more efficient solar cells and decreases cell processing costs by reducing quantities required for a given output (Green, 2019).

- The innovation progress in the solar PV industry are in materials, module manufacturing, applications, operation and maintenance, an d in ways of decommissioning panels and managing their end of life stage (Figure 15).

Figure (15): Solar PV value chain(Global Data (2019), Solar PV module, Update 2019: Global Market Size, competitive landscape and key country analysis to 2022, (Global Data,2019. London)

-Important trends in operation& management innovation in the life cycle of a PV project can be grouped in two main categories: 1) smart PV power plant monitoring

by intelligent systems, such as drones for their capability to monitor largescale solar parks in less time(Green, 2019); and 2) retrofit coatings for PV for cooling PV panels for boosting solar module efficiency (Filatof, N., 2019f).
The future of solar PV employment is nonetheless bright, given the urgency for more ambitious climate and energy transition policies, as well as the expectation that countries are learning important lessons on the design and coherence of policies.

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تأثير الطاقة الشمسية على التصميم الحضري (دراسة حالة، مجمع الطاقة الشمسية الكهروضوئية في بنبان)

خلاصة:

في الوقت الحاضر، يعيش حوالي 50% من سكان العالم في المدن، وبحلول عام 2050 سيرتفع هذا العدد إلى 68% (الأمم المتحدة؛ 2014). تستهلك المدن أكثر من ثلثي الطاقة الأولية في العالم وتطلق أكثر من 70% من الغازات الدفيئة في العالم. باعتباره مستهلكًا رئيسيًا للطاقة، يمثل قطاع المباني 28% من إجمالي انبعاثات الكربون العالمية وستستمر هذه النسبة في النمو خاصة في البلدان النامية. لقد وضع التحضر السريع عبئا ثقيلا على البيئة والطاقة، مما يعني أنه يجب اتخاذ تدابير فعالة لتلبية الطلب المتزايد على الطاقة في المناطق الحضرية. يعتبر تقليل استهلاك الطاقة في المباني وزيادة استخدام الطاقة المتجددة من أكثر الوسائل فعالية لمواجهة تحديات الطاقة الحالية، وقد أصبح هذا الرأي محل إجماع صناع السياسات والباحثين. في السنوات الأخيرة، اكتسبت الطاقة الشمسية شعبية كمصدر للطاقة المتجددة، وبرز دمجها في تصميم المباني كعنصر حاسم في إنشاء منشآت مستدامة وموفرة للطاقة وتقليل انبعاثات الغازات الدفيئة وإجمالي البصمة الكربونية لهيكل المبنى. إن استخدام الطاقة الشمسية في التصميم المعماري يمكن أن يساعد في خلق بيئات داخلية أكثر صحة لسكان المباني، ويساعد في خفض تلوث الهواء الداخلي وتحسين جودة الهواء الداخلي بشكل عام عن طريق تقليل الحاجة إلى مصادر الطاقة التقليدية مثل الفحم والغاز الطبيعي. بالإضافة إلى ذلك، يمكن للمبنى توليد الكهرباء الخاصة به عن طريق إضافة الألواح الشمسية، مما يلغي الحاجة إلى شراء الطاقة من الشبكة. وبمرور الوقت، يؤدي ذلك إلى تقليل تكاليف الطاقة وتحقيق عائد على الاستثمار. إحدى تقنيات الطاقة المتجددة الواعدة هي الطاقة الكهروضوئية (PV) وهي وسيلة أنيقة حقًا لإنتاج الكهرباء في الموقع، مباشرة من الشمس، دون الاهتمام بإمدادات الطاقة أو الضرر البيئي، إنتاج الكهرباء من ضوء الشمس، بصمت دون صيانة، لا تلوث، ولا استنزاف المواد. وإلى جانب طاقة الرياح، ستقود الطاقة الشمسية الكهروضوئية الطريق في تحول قطاع الكهرباء العالمي. سترتفع القدرة المركبة التراكمية للطاقة الشمسية الكهروضوئية إلى 8519 جيجاوات بحلول عام 2050 لتصبح ثاني مصدر بارز (بعد الرياح) بحلول عام 2050. علاوة على ذلك، يتكون نظام الطاقة الكهروضوئية المتكامل للمبنى (BIPV) من دمج الوحدات الكهروضوئية في غلاف المبنى، مثل السقف أو الواجهة. من خلال العمل في نفس الوقت كمواد غلاف المبنى ومولد الطاقة، يمكن لأنظمة BIPV توفير وفورات في تكاليف المواد والكهرباء، وتقليل استخدام الوقود الأحفوري وانبعاث الغازات المستنفدة للأوزون، وإضافة اهتمام معماري للمبنى. بحثت الدراسة البحثية في مدى أهمية العوامل الحاسمة مثل خط العرض والموسم؛ الحجم والأبعاد والتوجه. يمكن أن تؤثر

مواصفات السقف والمناخ المحلي والخصائص الأخرى لموقع تركيب الخلايا الكهروضوئية على كمية الطاقة الشمسية الممتصة والتي بدورها يمكن أن تؤثر على جدوى وأداء اللوحة الشمسية. لذا، فإن الهدف من هذه الدراسة هو تقييم تأثير تطبيق الطاقة الشمسية الكهروضوئية على المشهد الحضري مثل قرية بنبان بأسوان لحشد الاستثمار الخاص للمساعدة في بناء أكبر محطات الطاقة الشمسية الكهروضوئية في العالم وكذلك تحفيز النمو الاقتصادي وخلق فرص عمل مباشرة وغير مباشرة. في مرحلة بناء المشروع، تقليل الانبعاثات الضارة عن طريق تغذية المنازل بالطاقة النظيفة، وإطلاق المزيد من المشاريع الضخمة في جميع أنحاء البلاد لمصر جديدة من خلال اقتراح خطة مكانية متكاملة لمجمع مجمعات الطاقة الشمسية الكهروضوئية في بنبان (جراند بنبان). ويتم تحقيق ذلك من خلال إدخال مستويات مختلفة من الألواح الكهروضوئية على الواجهات السطحية بحديقة بنبان بأسوان. كما تهدف مثل هذه المشروعات إلى إقامة مشروعات عملاقة في جميع أنحاء البلاد من أجل مستقبل أفضل لمصر. أظهرت النتائج أن الانسجام البيئي وتوليد الطاقة والتصميم المبتكر وارتفاع التركيب والتقنية والفوائد الاجتماعية للنظام الكهروضوئي هي التأثيرات الرئيسية للنظام الكهروضوئي على المشهد الحضري وستكون أسوان حجر الزاوية في مجال الطاقة الشمسية في جميع أنحاء العالم. فى المستقبل. وفي الختام، يوجه هذا البحث تركيز التخطيط والتصميم الحضري والمدن على تطبيق الطاقة الشمسية وتأثيرها على الاقتصاد ويوصي بالاتجاهات البحثية المستقبلية في التخطيط الحضري الشمسي.