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An Investigation of Socio Economic and Technical Factors, of Design Rooftop PV Systems Towards a Sustainable Energy in a Developing Countries, Settlements-Khartoum Sub Urban (AL-Azhari City)

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ABSTRACT

Urban development is generally associated with the phenomena of human life. effect the type of life, nature and structure of services and renewable energy as a solution of the lake, in the suburban area in the development of countries and relationships. Essential services and infrastructure represents a major challenge to the critics responsible for urban planning formal and informal. Therefore, public policy on regional institutions and the level of the city and the country are preparing for a comprehensive approach for optimal management of energy demand renewable in the future and try to determine which are sufficient to meet the city Khartoum citizens Al-Azhari it's an urban area of focus this type of technology. This study summerise of the essential fields for documentation of the population daily observations and opinions and also aligned with the focus on environment, took the technological, social, legal and economic factors in the current Al-Azhari city essentially of basic services. Records of the location of the training and that of services and the current development, power over the location of houses in the area of Al-Azhari. This article find out of main results that the requires the development of future population and to identify the current conditions in Khartoum city and determine the future decision Health and renewable energy and low energy building design and by appliding the pv system upon the roof as clean Energy of urban planning in developing countries like Khartoum state.

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Key Words

Design rooftop, PV systems, AL-Azhari city, sustainable energy, Khartoum

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INTRODUCTION

Due to the restricted availability of traditional energy sources, the environment has deteriorated to the point where pollution, acid rain, global warming, and other issues may be observed[1]. Therefore, it is essential to produce green, clean energy from renewable sources. One of the most encouraging environmentally friendly power sources among all environmentally friendly power sources is solar energy. because it is copious, easily accessible, and potentially profitable. The performance of photovoltaic modules and building integrated photovoltaic systems is highly depending on (BIPV) either modules of guidelines. The photovoltaic modules needs-based and also Peak to the maximum sun exposure and avoid unwanted shadows. Most final studies on the problems of quality and quantity on a certain location. One of the most attractive aspects of photovoltaic's is that removed by the site power generation construction, distribution, distributed generation of energy transfer from a regional power centre[2]. Grid-connected, power systems are gaining in popularity and this trend should continue and it is a common feature of future buildings, one of the technologies for renewable energy is more talented photovoltaic (PV) energy. By using this renewable energy source that could reduce our dependence on non-renewable energy sources[3]. The trivial solution of a single cell at the optimum angle of inclination is not practical for many technical reasons or, sometimes, the collector height is limited. It is therefore an optimal solution for the use of the collectors in a given field the energy collected, as well as from the economic point of view Samanta[1] found that Solar photovoltaic technology could harness the sun's energy to provide large-scale, domestically secure and environmentally friendly electricity[2]. All buildings will be built to combine energy-efficient design and structure practices and renewable energy technologies for a net-zero energy building. In fact the building will protect enough and produce its own energy supply to create a new generation of cost-effective buildings that have zero net annual need for non-renewable energy. Photovoltaic brought a new perspective for building design strategies. However, this technology is not mature enough and its adaptation to architecture is satisfactory new Character solar module are connected together and encapsulated in different materials to form a module. The standard component of a BIPV system is the PV module as Samanta[4] and Lopes[5]. The modules are united together in forming an electrical series with cables and leads to a PV system. Direct or diffuse light, shining on the solar cells induces produce the photovoltaic effect unregulated direct current DC power. These DC can use and a battery system, or synchronized fed to an inverter and turns the power into ampere current AC. The electricity can in the building or exported to a public entity by a grid interconnection, or will be sent from the grid. The main reason for the integration of the PV system in the building, the energy requirements of the building to reduce stress[4,5].

MATERIALS AND METHODS

Additional justification of PV system insulation in a domestic used: This article used a method of design the PV system with adds to the architectural design by being integrated into the total design of the building. The PV provides a visual statement that can either offer subtle or substantial changes to the architectural dynamics of the building. The housing building's PV of sloped roof. The PV system which was design by researcher is applied architecturally and teachniqlly. This solution was chosen because the entire project is of historical significance. A modern high-tech material would clearly not be appropriate for this architectural style. That obtained the society in Khartoum was accepted all new modern architectural which can solves the needed of service and can solve the backing problem[6]. PV System of urban design in location study location determines the architectural representation. The PV system is used as an integral part of the building envelope and thus espouses a core building characteristics. Using PV to dominate the roofs cape and aesthetic feet of the area. The blue-colored PV roof, while unconventional, blends effectively with the water and sky vista in PV revitalizes what might have been a stereotypical glazed corridor into a prominent feature playing an important role in the total image of the building[7].

The researcher defines The PV system leads to new architectural concepts. The application of PV modules, particularly in combination with passive solar design concepts, leads to new designs and new architecture in Khartoum and ability to complement this study in Khartoum in domestic sector.

Studying location (Alazhari City-Khartoum) guide: It is an applied study in the location (Al-Azhary) in the block (10) as an example of the handle of BIPV and the use of renewable energy in 2019 as a project of the government in Khartoum and Block (29) do not implement the experiment block record 10 of the draft planning and architectural integration of the area and the design of the house as a city architectural integration with the requirement of compliance of the entire design life of these people in the field of population and cities. Through steps of public services in connection with this study:

- Recognition, collection and analysis services for residential areas in the city of Al-Azhary. Including the three classes[8]
- To identify the role of citizens and their duties to the representation essential services

Fig. 1: Location of Al-Azhari city at Khartoum State

- Identify the functions of government in providing essential services and efforts, the citizens, to minimize the suffering and meet their daily needs
- Identification of the major elements for the solution of these problems and study for the future existence of the provision of such services
- Determination and the limitations of the current system used in the provision of services, including networks of different quality according to national and international standards and try to understand the reasons for the restrictions
- Direct pointing suffer harm as a result of the lack of weighing services

Historical and geographical background

Geography of the area: The city of Al-Azhari is located in the South of Khartoum, it is bordered: From the east by the high way that connecting Khartoum with Wad-Medany, by the west is the local market and in the Al-Sahafa regularity and by the north is Al-Ingaz city and by the south is bordered by Idd-Hussain and Soaba cities, in addition to the same as showing in Fig. 1, the Concerning the situation the area was complement to Khartoum province in the period 2016-2018 and 1998 then to Jabal Awlya province in[9,10]. Because of this causes of unique and spatial location of court of Khartoum state. The area was chosen for this study of tow scope of facility and future of using BIPV technique[11]. The researcher takes this city of tow phase of this study:

- Surveying phase because it has case of BIPV in a housing as the one of the first cities using this kind of technique, at block No. 10
- Modeling and design BIPV system at block No. 10
- Design the houses of unplanned area of this city block No. 29
- Working the experiment to find the optimal direction and optimal angle as well as to apply the result of these experiments for Khartoum state.

Historical planning of the area: The researcher creates It is planned on the bases of Khartoum general planning policies for the year 2001[10], these policies includes. Planning of unplanned spaces in different cities and extensions, furthermore planning central cities with sufficient services in addition Promoting rural area south of the green belt including Al-Azhari, in order to provide urban infrastructure. Establishing huge industrial settlements near these central cities as to get most of the working power in the inhabited area by means of create agricultural areas through these cities as to provide production and employment opportunities for the population in addition to The area is connected with center of Khartoum through (Medany high way) and connected with Al-Ingaz, Mayo and Idd-Hussain cities.

Surveying component of location study: This article is applied to the area under study, which is Alazhari City, through personal meetings with individuals in government and at the local level, by direct

observation of the area and the population as well as the public services related to this study. Surveying, registering and analysing the services rendered to the inhabited areas in Alazhari City, including its three classes. The main Objectives of The Survey in the urban design to demonstrates the importance of well-defined objectives in the location of the study: Collecting data to be used for further user. Assessing the public perception of the acceptance of PV technology can be considered a more effective strategy in applying the programmes for the adoption of this technology, not only to identify the issues facing the residents of the location studied in the provision of PV system. Developing PV system as a variety of roles of the authorities, communities and the householders in the location.

Main aspect of study is u RBAN and environment aspect: Studying health and environmental threats because of improper usage of services and how individuals are affected by improper environmental behaviour and the role of formal authorities in the occurrence of this phenomenon.

Field study procedure of research sample: The study tested the samples through a random selection of localities at Alazhari City. At that point, the researcher started selecting a sample in Alazhari City Block No.10. This involved 723 households of which 260 were used BIPV. The researcher refers here to those members of the community who use BIPV directly. These citizens have a right to have input into where their contributions are being spent. Even in locations where communities have voiced a majority of disapproval for new facilities, they have been built anyway. Furthermore, the exclusion of concerned citizens negates the possibility for conversation towards innovative social change and holistic inclusion as stead by Baetens and Cannavale.

Method of simple random sampling: The stated objectives of statistical application are the collecting, presentation, analysis and interpretation of data. The first process is collecting information. The assumption of the randomization applied in data collection is the foundation for most methods for statistical analysis. As Zhang *et al*.[11] found the applications of statistical analysis and the related interpretation of the analysis are useless when the assumption of the randomized controlled of sampling cannot hold. Therefore, before studying the methodology of statistical analysis, one must obtain knowledge on sampling. Obtain a representative sample of eligible respondents and a list of households. The database randomly selected 50% of the total number of households (n = 249), which was 50% of households that used BIPV. The list indicated each householder's name, mailing address and race of each potential respondent. The focus for selecting a random sample is on the statistical methods of sampling and estimation. It focuses on the applications of sampling, covering the design and implementation of sampling for the surveys, including the three different questionnaires that were used. The researcher chose the sample from Al-Azhari City Block No. 10. Of the 723 families that live there, 294 use a BIPV system. The researcher took a random sample house by house and the sum of this sample was 147 (50%) of the basis of the field of study.

RESULTS

This article anlysied and evaluation the urban situation This section may be divided by subheadings. It should provide a concise and precise description of the survey results, their interpretation as well as most important that can be found.

An urban planning of Alazhari city: It is cautious as the most central modern cities characterized as a result of the bordered by the main street which is breaking into other main branches as well as all blocks in central cities is consisting of 50-100 thousands person[12]. Although the shape of the city includes different classes and blocks it is planned with both vertical and horizontal roads. It has a main center introduce the different blocks. This type of planning has some difficulty and need to be improved and efficient[12]. Intended for motive that the researcher attitude this crisis when designed and planning the un planned area at block no. 29, furthermore not far-off diverse from the blocks planning of the intact city of Al-Azhari, because it must be harmony with attractive beautiful. The main results was People are interested in cultivating trees along roads in all three classes. The city planned comprehensively with integrating all activities and different services as well as social and human services[13]. So there are 18 mosques and little number of nooks, There is only five basic school it is located in block (11), 10, 15, 23, 5. In attendance is another basic school under establishing, although it is not completed but it is started to receive pupil. The completed rooms are without doors or windows. And students walk far distant (about one kilometer) to reach to the school. Presence is only one health center in the area, it is located in block No. 15. It receives medium cases but it has no ambulance[14] as in Fig. 2. There is no market in the city that is because the city is located near Khartoum central market and the local market. All the organization in the city is funded publicly and through aid and donations by charity societies and citizens self efforts as Khader[15]. The

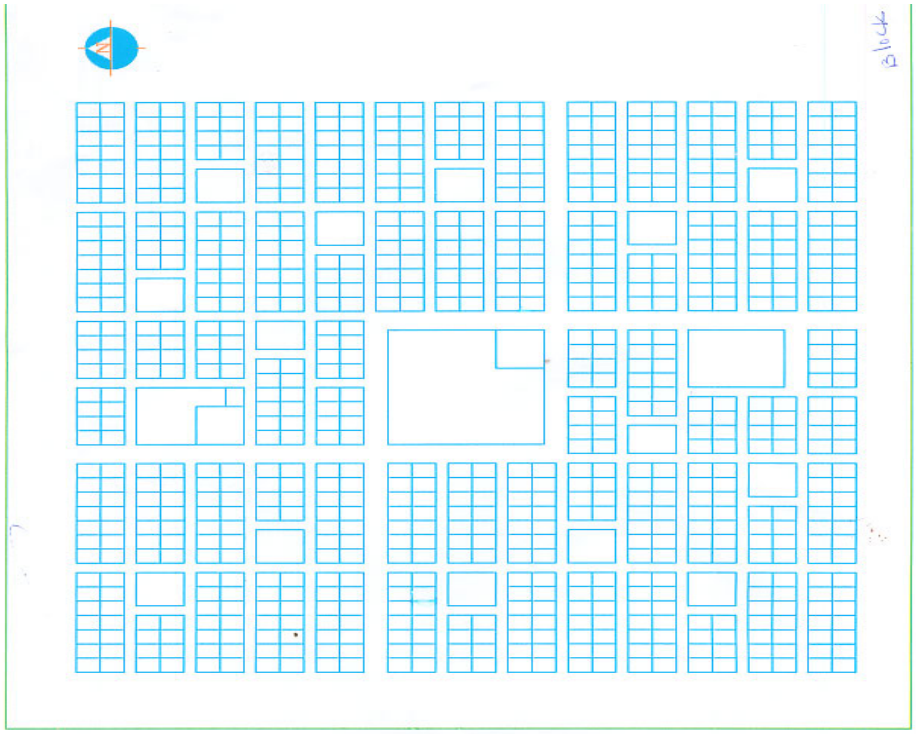

Fig. 2: Planning of block No. 10 Al-Azhari city, Khartoum state
Source: Ministry of planning 2021

Fig. 3: Al-Azhari city block no.10 the area which surveyed

current situation of the city is not satisfying the central modern cities requirements and is not meeting citizens' needs, which necessitate immediate treatment by public and governmental authorities. Blocks are similar in design and in general shape Grid planning as whole Khartoum state planning[13]. The services are extended from the first unit through to the centre of the city in Fig. 3 and 4.

Fig. 4: Al-Azhari city block No. 29 the area designed researcher

Table 1: Town planning regulation at Al-Azhari city block no. 10

	Wall materials							
Roof material	Gross	Mud	Mud bricks	Brick	Stone	Others	Total	Approx age (%)
Mud/earth	206	19.701	899	4.751	20	205	77.462	57
Baladi (wood)	20	9.549	200	9.045	90	241	24.476	20
Zink streets	30	3.442	109	20.521	43	250	14.474	11
Comment		-	5	3.012	93	432	4.541	4
Others	650	1.241	12	1.149	10	6.517	9.464	8

Architecture situation: The city is divided into three classes: consisting of 29 blocks (Fig 3 and 4). It is as pursue a First class represents 28.7% of the area which consists of (6) blocks that is (5247) Sections and the inhabited sections are (2098)[14]. Second class: It represents 13% of the city. It consists of 7 blocks 8, 9, 25, 26, 27, 28, 29 and the number of sections is (2469), number of population is (988) persons as resulted in this study. Third class: it represents 58.7% of the city. It consists of (16) blocks, (2469) sections, (4398) are the inhabited sections[14]. Number of sections in the city is (18710) persons and the inhabited sections is 38-41% in all blocks. The average of family members is about 6 persons. The total number of population in the city is about (52388). Numbers of population in the different classes and blocks in Table 1[16].

Housing condition in a location: The planned residential areas are categorized into two land classes According to the town planning regulation, these regulations define the minimum size as shown at According to official statistics[17], 1067 household tended to use mud for constructions of walls (table), since mud construction is not allowed in first and second class areas, the figure 65% is indication of the high proportion of third and lesser class areas using the material, brick (28%) is dominant in the higher two classes. Mod (roof construction composed of local woods skeleton and heavy mud on top and finished with animal dung for water proofing)[18]. (Baladi) and Zink (corrugated galvanized, Iran sheets) roofs account together for 78% of household in Al-Azhari, again indicative of predominance of third and lower classes where the use of these materials is allowed and the most important material which was use on top of the roof[19]]

House type: The private house can be (villa-type) bungalow or other type. Bungalow or other type of dwelling having usually one or two stories, with having courtyards within a plot and surrounded by boundary walls, fences or hedges, occupied by one or more households[20]. Block of flats is the plot sizes are 450-550 square meters in first class areas. 350-450 square meters in second class areas. And 350-300 square meters in third class areas. Table 2 as a researche found in the result The density in the first and second class areas is between 20-100 person per hectare (average 60) and between 50-150 (average 130) persons per hectare in the third class areas as conclude in the analysis.

Family structure in the city: Family structure comprises family size and family type. The total households number in greater Khartoum is 853.017 and of AL-Azhari city. Family Size in the location Family

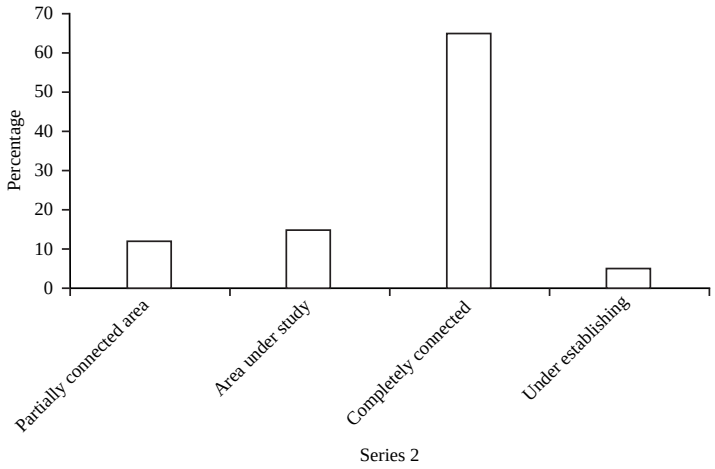

Fig. 5: Electricity networks in the city: Descriptions and situation

Table 2: Dwelling typologies

Type of living quarter	No. of households	No. of population	Total household (%)
Bungalow 1 floor	413.26	2587	92
Bungalow, multifloors	9.43	95	3
Villa or flat	5.59	610	1
Qottia	7.98	84	1
Others	16.02	90	3
Total	55317	3014250	100

Table 3: Incomes groups

Income	No. of population	Percentage	Income	No. of population	Percentage	Income$
High	1650.000	5	>10000	265.000	5	>10000
Middle	3300.000	10	300-100	795.000	15	3000-1000
Low	2.805.000	85	0-300	4.240.000	80	0-300

size varies in Table 2, it forms pyramid starting from households with one person and reaching the maximum at households with 4 persons, then descending unit reaching households with 7 persons and a little at households with more than 8 persons[21]. Family type in greater Khartoum, unclear families comprise less than 50% of the total number of families. This phenomenon is unique Sudanese family feature as traditions encourage daughters and sons to live in their parent house after marriage forming extended families. And financial disabilities and other reasons such as seeking work or education in the capital force other to live with their relatives forming composite families[22]. Education Level As greater Khartoum level Al-Azhari city, the literacy ratio is high (27.3%) of the total population above the school age is illiterate and the portion of the population who have higher education is very small 3% details of educational level of the Individual's Standard of Living There is no clear differences in standard of living among people in different classes, which is most of the people, are of limited income i.e. they are employees, labors or little traders. The income average is not less than SD 50.000 as minimum[23]. Houses holders' is 98% of the population and this high percentage gives advantage for developing the area. This percentage of income was similar to El-Bushra[20] which was found at the percentage whole Khartoum state this clear at Table 3.

Building services and conveniences: The basic services, such as water supply, drainage and sewage and power supply in the residential areas of Al-Azhari city. The researcher will concern with the energy situation because of deals with BIPV[24].

Energy in the city: Electricity represents the basic energy in the city. People depend mainly on electricity as it is cheap it is operating all services in the city. It is importance is clear in lighting. The national electricity corporation is responsible of providing the area by electricity. The blocks numbered (10, 12, 19, 15, 4) are completely provided by electricity that is per (3, 2, 2, 2, 1, 2, 3) transformers systematically[25] with capacity of (433.11/KW). The Network cables are suspend and carried on of different diameters 70 mm^2/km and with average length of 55.000 mm^2/km[26] and Some people use Kerosene in cooking and lighting with a percentage about 75% and gas 15%, in blocks those have no electricity. Energy used for especial purposes other than lighting is gas which is used in cooking by 55% then charcoal about 35% in all blocks[27] as in Fig. 5.

The cost-effective of using electricity: According to the national electricity corporation policies that the blocks those which are inhabited by up to 37% have the right to have electricity[19], the citizens have to pay 33% of the total cost to the national electricity corporation

Table 4: Electricity consumption for household appliances used in rural Sudan

Appliance	Power Use Wh per day	Daily energy use Wh per day	Used in solar systems
15 watt incandescent light bulb	3	45	Often
10 watt fluorescent lamp	3	30	Often
14" television	3	210	Some time
Radio/cassette player	6	6	Often
Cellular phone (charging)	3	6	Often
60 watt incandescent light bulb	3	180	Very rare
Small refrigerator	12	960	Very rare

which will provide electricity according to its own policies. Citizens are to pay electricity expenses according to their consumption individually.

Social characteristic: Some aspects should be considered in providing and extending electricity to the different blocks are, Identify the inhabited areas which lack electricity. Dividing these areas into parts and blocks[19]. Statistical check for the population percentage, the financial ability of citizens. Public committees have to reflect citizens' desire of their need to electricity. The fees electricity is high because of political situation in Sudan after 2019 and depend on Ministery of electricity in 2022-2023.

Technological impact: During the four coming years electricity network will be extended to all blocks which are not lighted. Only 13% of the blocks in the city has been provided by electricity. Blocks numbered (1, 2, 3, 4) has provided by electricity partially and it is connected to Al-Ingaz city it represents 13.8 %. Blocks numbered (9, 15, 4) are partially connected to the general electricity network in an advance stage it represents 10%. Blocks numbered (11, 16) which represents 7%. the work is still running for establishing and extending the network. The counters used in measuring consumption are those old ones which uses the deferred paying system. Main maintenance to disrupts which affect the general network is done by the National Electricity Corporation. There should be primary and secondary electric stations near to the elected blocks. These extensions will be executed by the national electricity corporation engineers. The study is done typical to technical specifications of the network program by 85%.

Availability of PV systems: The average of output of power of homes using PV system in Sudan is about 0.25 KWh per day) of the users. The system was used in different households in Khartoum produces about 30 kWh per year. Most homes use a battery system (10-30 kWh per year 2006)[28]. Table 4 for approximate power for common appliances in the solar battery and households connected to the network. It is based on estimates of typical levels of energy use included in gross assumptions about the number of hours the electricity was consumed in one day[28]. The amount (daily energy consumption) is to determine the critical value that devices can be used in a small house BIPV system. With this much power, some devices (lighting, i.e. TV, radio/cassette players and mobile phones) and the energy appliances of small solar power system-(domestic appliances) (e.g. refrigerators, irons and kitchens) cannot support this. This brief analysis shows the difference in energy consumption opportunities between households with solar panels and battery use, on the one hand and those with connections to the network, on the other.

Power distribution systems BIPV houses support PV systems: The data in Table 8 also show differences in energy consumption between Equipment used in BIPV. For example, radios and mobile phones Using very small amounts of energy, while the lights and televisions consume relatively more Quantities. There is also a significant difference between the incandescent lamps (bulbs) and Fluorescent lamps. Fluorescent lamps are more efficient generally three to four times that bulbs 100. This means that a 10-watt fluorescent lamp provides more Light output less power than a 15 watt light bulb[28]. However, low power consumption, low Incandescent bulbs are still common in rural solar systems in Sudan since the first It costs about a quarter as much as fluorescent lamps[29]. Electronic data information monitoring in 40 homes in Sudan in 2005 and 2006, provides detailed information on patterns of distribution of energy for households that use solar energy electricity. In Fig. 7 and 8 show that a greater proportion of the energy assigned to the lighting in larger systems (>25 watts), while the television is dominated smaller plants (<25 Watts) as Matthew[30] that mean it can be installed. Radios and cell phones are a burden relatively small amount of energy in both systems, although the use of radio is relatively larger proportion of smaller systems. These results show the high priority that uses the connective tissue and especially television-In rural households in Sudan[17]. In smaller systems where the availability of energy is limited, most of the energy is spent on television. A smaller but still substantial part goes to the radio and associated with the combined power to the radio and TV representing approximately two thirds of the total production. As the system size increases, the results suggest that the number can diminishing returns Demand for television and radio, with the excess energy is allocated lighting[31]. This hypothesis is supported by data on the utilization per hour for each

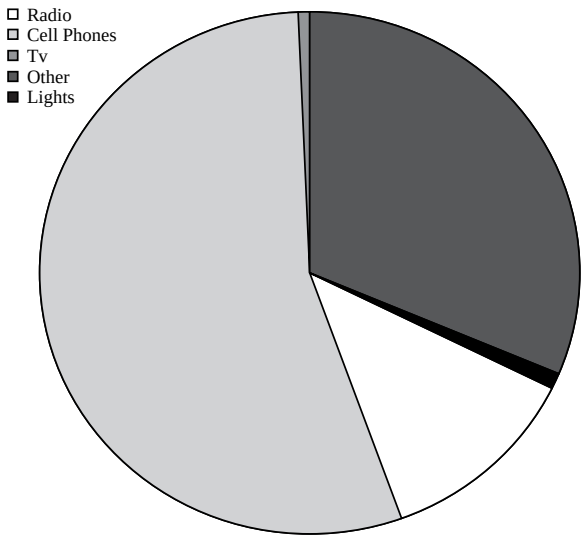

Fig. 6: Mapping of solar systems more than 25 watts

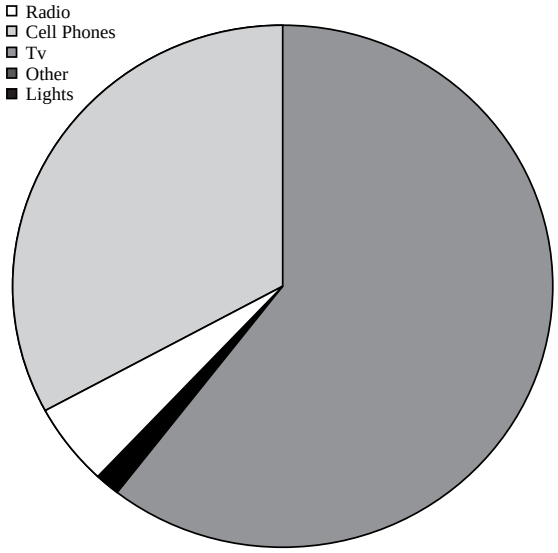

Fig. 7: Distribution of solar energy use in smaller systems of 25 Watts107

Devices. In smaller facilities (<25 W) TVs used on average 2.1 h a day, be with the radius of 4.8 h and lights used for 1.5 h. In the larger systems in the sample, the rate of use of radio and television are not increased (2.1 and 4.2 h per day, respectively) but increased use of lighting, an average of 7.6 h daily[13]. These findings have important implications for the social significance of solar energy Electrification. They suggest that television and radio can be used in connection with small and large, lighting applications related to solar energy much more common in large systems (eg> 25 watts). In this study In Sudan, unsubsidized solar Market, access to sunlight strongly influenced by the purchasing power. Therefore, use of solar energy due mainly to the rural middle class. is limited but there are also important pay differences between middle-class families, a system. Figures 6 and 7 show that the illumination of the use of solar energy could be more common in wealthy families who can afford a larger system in their slightly less rich Neighbours' who cannot afford a small solar system.

CONCLUSION

to determine the best urban planning and architectural design for domestic use using PV systems at Al-Azhari city resources in block 10, 29 and to complete the survey procedure for Al-Azhari city

block 10, it followed the epistemic existing citizens experience in the different blocks. This article analyzed all of the case study location's data and it is mainly determined on the following: Historical and geographical case scanning that aid in understanding and developing services provided to Al-Azhari city residents. Planning for Al-Azhari city's urban areas, the surveying, registration and analysis services provided to populated areas in Al-Azhary city, including its three classes, to identify the varied responsibilities of the authorities, communities and home owners in the provision and applied PV. The government policy on regional organizations and the level of the city and the country are preparing for a comprehensive approach for optimal management of energy demand renewable in the future and trying to figure out which are sufficient to meet the citizens of the city of Khartoum in the Alazhari it's an urban area of focus. The environmental focus of this study meant that the technological, social, legal and economic issues in the present-day Al-Azhari city were essentially reduced to the provision of fundamental services.

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