Place of Photovoltaic Solar Energy and what Impact on the Environment

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Abstract
The reatest climate concerns, according to the diagnostic of the climate change effects seen in the city of Bukavu/DRC are drought,late and occasionally violent rains, and even the elimination of certain water supplies or water sites. The significant contributions to climate change include deforestation brought on the consumption of charcoal and other fossil fuels, which are used 97% for cooking and 32% for lighting. it is crucial to comprehend the efforts being made by solar panel importers in the area to address climate change and find a socioeconomic answer. Understanding the perceptions of the people living in the city of Bukavu toward the effects of climate change is the main goal of this paper, it is based on research that was done using surveys and interviews with 455 homes about energy usage in general and solar energy in specific. The results have shown that the population of the city of Bukavu are the most vulnerable to a reading of climatic phenomena essentially based on locally constructed knowledge.

Keywords: *Consumption, Solar Energy, Photovoltaic, and Environmental Impact.*

I. INTRODUCTION

The majority of the energy on Earth comes from solar energy, which the sun produces as a result of thermonuclear fusion reactions and may be used to generate electricity. Solar energy is constantly replenished and moves through space as "grains" or energy quanta called photons. The idea of the solar constant was first suggested in 1837 by the French physicist Claude Pouillet. When the Earth is at an average distance from the Sun, he observed that the strength of solar radiation, as measured at the outer edge of the Earth's atmosphere, is essentially constant. This constant, 1350 W/m2, changes by around 0.2% every 30 years. Due to the fact that there is less solar energy accessible at the Earth's surface than the solar constant, the amount of solar energy captured also depends on the orientation of the receiver, as well as the day, time, and latitude of the receiving point, as well as the absorption and dispersion of this energy, caused by the interaction of photons with the atmosphere, clouds, or even fumes produced by pollution. At the present time when fossil fuels cannot ensure the sustainable development of humanity and their use constitutes an absolute risk, and appropriate CO2 capture technologies are not implemented, renewable energies are emerging as an alternative in this context consisting in inventing the mix energy of the next decades, because they do not offer the same risks and their advantages are on the other hand largely complementary.

- *Paper Organization:*

The following is the organization of the paper: Section II provide the Literature Review, Section III develop the Methodology, Section IV is Result and Analysis, Section V presents the Paper Conclusion and References at the end.

II. LITERATURE REVIEW

A. Review of the Photovoltaic Solar Energy

M. Arkoub and R. Alkama (2009) [1] assessed that the growth of photovoltaic solar energy will be fuelled by increasing the fundamental benefits, which are still quite alluring. It is capable of being integrated and customized for application, and it covers all power spectrums. Concentrator solar power replaces the much more traditional power plant; the produced electrical energy must be transferred to the location where it will be used. High temperature heat is also produced by CSP technology. She benefits from this by being employed in both oil fields and seawater desalination plants. CSP is a technology that has both an economic and political approach. These technologies today undoubtedly only address a small portion of the demands in the world. Power productions are expected to be measured in terms of GW during the course of the next ten years, and in the medium term, their contribution will be such that a reversal will be impossible.

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B. Review on Environment Impact

Cécile Bordier, 2008, [2] assessed that two fundamental texts serve as the foundation for European energy policy with regard to the advancement of renewable energies and climate change: first, the European Directive of 2001, whose goal is to increase to 21% the share of electricity produced from renewable energy sources in the gross electricity consumption for the EU-25 in 2010; second, the 2003 Directive establishing from 2005 a community emissions trading system1, which submits the sectors with the most emitted greenhouse gases to trading obligations. The goals of these two programs are similar: creating renewable energy might encourage power companies to stop using particular fossil fuel-based production methods, making it easier for them to comply with the European CO2 quota trading market.

Benjamin Kajibwami, 2015 [2] assessed that the National Energy Commission (CNE) measured the amount of sunlight in the ground level as part of their research. The nation lies close below the solar belt on the equator. The DRC has significant solar potential. The DRC is in a very high band of sunshine, with measurements made at several meteorological stations across the nation showing values between 3250 and 6750 Wh/m^2/jr. Given that 1 kWh/m^2 is the required minimum for electrification with photovoltaic systems, it is clear that solar energy has a tremendous amount of unrealized potential. Average daily global radiation and sunshine amounts in Bukavu are 4.60 Kcal/m^2 and 5.34 kWh/m^2, respectively.

➢ *Solar Energy in Natural Environment*

16.1015 kWh of the visible light spectrum are received by the earth's surface annually (equal to 180,106 GW of continuous power), of which 45% is absorbed, 30% is immediately reflected into space, and 30% is heated and emitted as infrared. The remaining 25%, or an average of 45.106 GW (Multon, 1998), is used to fuel the hydrological cycles (24%) and photosynthesis (0.06%). Solar energy is the power that the sun radiates, either directly or indirectly. Most forms of energy chemical, thermal, hydraulic, and electrical are produced by the Sun's light energy. For instance, the formation of fossil fuels like petroleum, natural gas, and carbon dioxide was the result of long-term storage of solar energy by organisms. In actuality, the only energy source that does not derive from solar energy is nuclear energy. It can be converted into other forms of energy useful for human activity via a variety of processes, such as heat and electricity [3]. As only 0.0018% of the world's electricity is produced using various solar energy production techniques, they are relatively uncommon. Due to the changeable nature of the sunshine and its sometimes-difficult to forecast patterns based on the time of day, the prevailing weather, and the season, the solar resource is more or less available in the city of Bukavu. The intensity of daily sunshine varies greatly depending on the season everywhere on the planet. In Bukavu, for example, the amount of sunshine varies significantly depending on the weather because cloud cover reduces sunlight, which in turn reduces energy production. This has a proportionate impact on how much photovoltaic energy is generated. But let's not forget that the country's wealth, not its aridity, is the factor that most contributes to the growth of solar energy utilization. Because it can be seen that the countries that produce the most solar- generated electricity are not the ones where shadiness is the most significant factor: Germany and Japan are the nations that generate the most solar-generated electricity. In light of this, the potential for renewable energy sources in the South Kivu is far from being fully realized, mostly due to the low level of political interest they tend to generate and the high investment requirements. These renewable energy technologies, among others, have the potential to significantly improve energy security and access to modern energy services while supporting the growth of the energy sector in the South Kivu, and specifically in Bukavu. Increased utilization of renewable energy sources is one of the prerequisites for sustainable development. They have advantages in resolving issues with energy, the environment, and economic and social development [4].

III. METHODOLOGY

A. Study Area

The city of Bukavu, the capital of the eastern DRC province of South Kivu, served as the site of this study. The province of South - Kivu (64849, 1 km^2), which is a mountainous area overall, has an eastern portion that is known as the South - Kivu mountains. East of the nation, in the West African Rift, between 2°26'-2°33' south latitude and 28°49'-28°51' east longitude, is where the city of Bukavu (64,310 km^2), or 11.8% of the province of South Kivu's total area, is situated. This region has one of the highest population densities in the Democratic Republic of the Congo, with an average population density exceeding 200 people per km^2 [5].

It is the highest city in the nation, with an average elevation of 1612 meters. Its 64,310 km^2 territory is spread primarily on dry ground (45 km^2) and South Kivu's seas (19 km^2). constructed at a height of 1463 meters on the beaches of Lake Kivu. Constermansville was the name given to the city when it was founded in 1925, during the Belgian era. Its borders are Lake Kivu to the north, the Ruzizi valley to the east, the territory of Kabare to the west, and the Ruzizi valley to the south, which serves as its nearest rear base in terms of both local labor and raw materials.

It has a tropical environment with dry seasons (July to September) and low altitude subequatorial or humid tropical climates. The average temperature is 20°C. The city of Bukavu had 60,850 inhabitants (1960), 848,081 inhabitants (2010), 870,954 inhabitants in 2012 and currently this population tends towards more than one million distributed in 3 urban communes: Bagira, Kadutu and Ibanda with 13 neighborhoods (Kasali, Nyamugo, Cimpunda, Mosala, Nkafu, Nyakaliba, Kajangu, Ndendere, Panzi, Nyalukemba, Nyakavogo, Lumumba and Kasha) [6].

B. Approach Methodology and Data Analysis

The data was mostly gathered through surveys with a representative sample of the Bukavu city's population due to the size of the study region. A hybrid sort of survey was conducted. The questionnaire was designed to focus

on three main areas: the condition of the photovoltaic panels, consumption, and perceptions of the effects of using solar energy on the environment. Excel Microsoft let us to compute X2 and compare the results to those from our 2012 and 2015 study. The graphs were depicted by descriptive statistics. The X2 independence tests with a significance level of 0.5, are the statistical analyses used to compare the variations in energy consumptions. In November 2015, a study was carried out among 455 randomly chosen houses in the city to determine the usage of solar energy in various industries and households. With the premise that at least 95% of the population utilizes some sort of energy, such as electricity from solar, hydroelectric, fossils or renewable sources, this sample size was calculated using Bryan's formula. The data collecting step was divided into three phases: conceptual clarification, exploration, and detailed/in-depth study, which involved gathering quantitative data using a customized questionnaire.

C. The Conceptual Clarification Phase

The group interview segment was prepared during this stage. Concepts that capitalize on local knowledge are clarified for accurate data collecting. During the interview sessions in the homes accustomed to reading about climate disturbances, the conceptual clarity was made.

D. Exploratory Surveys

The interviews were conducted in focus groups composed of producers with experience in the activity of production of photovoltaic solar energy. To obtain quality information, groups have been formed in different municipalities surveyed, in their specificities. In order to determine the impacts on the environment, the interview guide prepared addressed the factors of climate change caused by the use of fossil fuels, in its manifestations, the implications on the environment, people (livelihoods), and the various measures established to cope with them.

The CNE measured the amount of sunshine on average per year, and the range was 3.34 to 6.73 kWh/m^2. The city of Bukavu ranks fourth in the DRC for solar system electrification at a minimum of 1 KWh/m^2.

Table 1 Global Daily Radiation and Sunshine (Annual Average) in the DRC

	STATION	Radiation (Kcal/m^2)	Sunshine (KWh/m^2)
1	Kongolo	5.80	6.79
2	Manono	4.70	5.45
3	Kolwezi	4.70	5.45
4	Bukavu	4.60	5.34
5	Bunia	4.20	4.87
6	Kalemie	4.10	4.76
7	Bandundu	4.00	4.64
8	Inongo	4.00	4.64
9	Kisangani	4.00	4.64
10	Goma	4.00	4.64
11	Mbandaka	3.90	4.52
12	Tshikapa	3.80	4.41
13	Mbuji-mayi	3.80	4.41
14	Lubumbashi	3.80	4.41
15	kindu	3.80	4.41
16	Kananga	3.70	4.29
17	Lodja	3.70	4.29
18	Kikwit	3.80	4.25
19	Kinshasa	3.30	3.34
20	Moanda	3.30	3.83
21	Boma	3.25	5.45
22	Matadi	2.80	5.45

IV. RESULT AND ANALYSIS

The Democratic Republic of the Congo is depicted in a stripe on the figure 1 and in table 1 to illustrate its exposure to sunlight and radiation due to its location on the Equator just below the solar belt. However, it was crucial to support these claims with empirical research and quantitative data. [7]

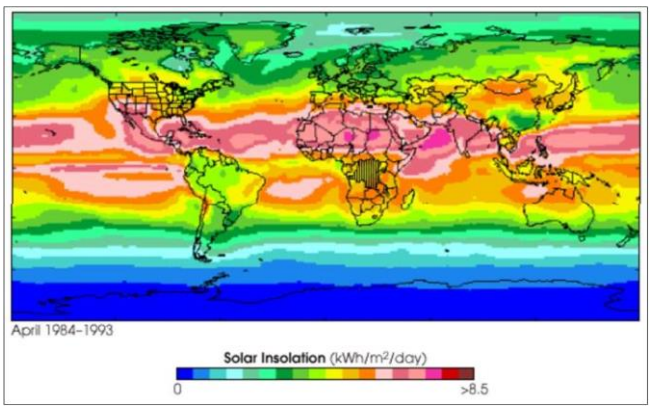

Fig 1 Solar Belt of the Earth Globe
Source : Earth Observatory NASA36

A. Energy Consumption in Bukavu for Cooking

The figure 2 depicts the energy usage for cooking, with 97% of households using embers as opposed to 61% of SNEL current and 3% of houses using exclusively electricity for cooking. This graph illustrates the strong dominance of fossil fuels in cooking. These findings suggest that solar energy is still not used for cooking.

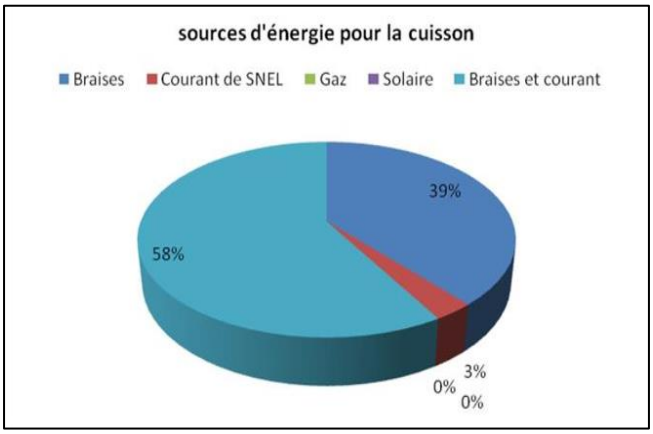

Fig 2 Energy Sources for Cooking for the City of Bukavu
Source: Metelsat Report, 1994 Quoted by the Inventory of the Energy Sector 2005 CNE

B. Energy Consumption in Bukavu for Lighting

According to surveys done in 2012, the electrification rate in the city of Bukavu is now estimated at 4.59%, the average amount of time people spend using SNEL electricity is estimated at 2 hours, and the only renewable energy source that appears to be utilized is hydroelectricity. Energy from the sun was still in the phase evolving [8].

The energy used to light homes in the city of Bukavu is depicted in the figure 3; 89% of households use electric current, which is becoming increasingly scarce due to frequent load shedding. The average daily usage of electric current is estimated at 2 hours, forcing households to turn to other fossil fuel sources like solar energy or generators, which are currently used by 32% of households.

Other homes that use power on a weekly or biweekly basis are SNEL subscribers, which promotes the use of fossil fuels. Solar energy is gaining popularity, even if it has only been used for lighting up to this point, with 7% of electricity coming from solar panels and lamps and 32% from generators.

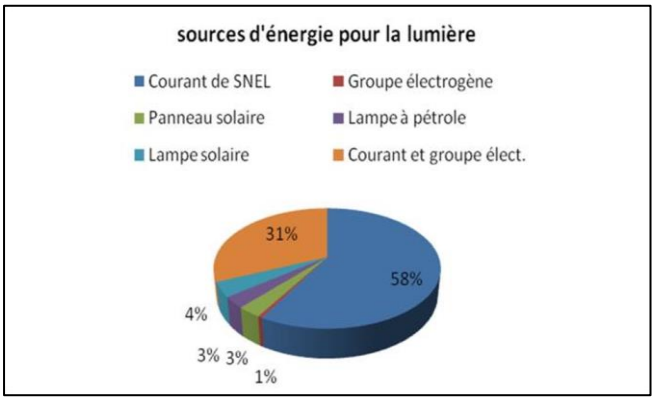

Fig 3 Energy Sources for Light for the City of Bukavu

C. Solar Panels for Lights and Appliances

From figure 4, according to our surveys, photovoltaic energy has ceased to be a curiosity for the inhabitants of the city of Bukavu to become a reality following the technical advantages and accessibility to all easily, movable and transportable, embedded and integrated on the use to make a single modular and extensible element. In June 2016, the UNDP had just acquired solar panels capable of producing 32 kW, a project that cost the UNDP an amount of one hundred thousand dollars. The figure 4 shows the frequency of use of solar panels in the city of Bukavu in households.

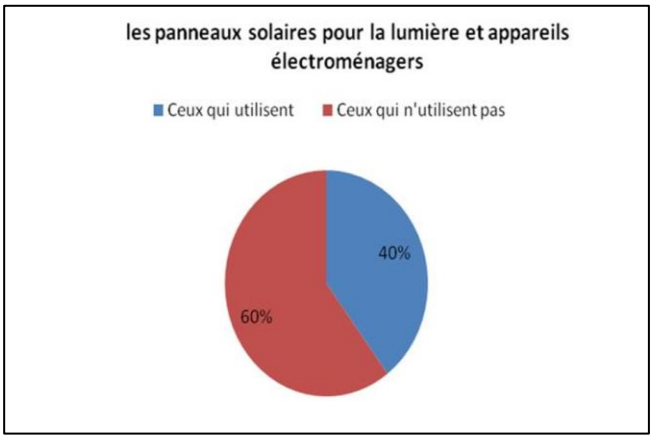

Fig 4 Frequency of use of Photovoltaic Panels

D. Solar Lights in Homes

The figure 5 displays the findings on the use of solar lights to use solar energy. Due to the socioeconomic advantages and positive effects on the environment, the people of Bukavu are determined to stop using kerosene lights and switch to solar ones.

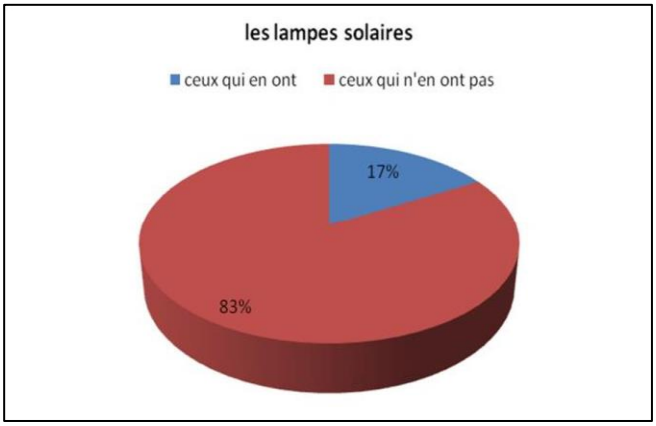

Fig 5 Use of Solar Lamps in Households

E. What effect on the environment will this have in 2050?

Our research indicates that over the past five years, Bukavu humanity has become more cognizant of the value of solar energy in all of its manifestations. Everyone is now aware that using fossil fuels results in higher costs and negative side effects, and that solar energy is a necessary alternative that is particularly advantageous from an economic and environmental standpoint. However, the Congolese government and investors have not yet realized how important it is to move away from fossil fuels, which have negative environmental effects and come from finite resources. The solar sector, which was hardly known and

not even frequented a few years ago, is now booming, and its consumption is steadily outpacing that of motors. However, the capacity of the converters is still insufficient to power household appliances like irons, electric stoves, etc. from where it is necessary then domestic equipment adapted to solar energy. The problem of continuity of operation and storage appears to have been solved. Due to South Kivu's and Bukavu's abundant sunshine, projects with a capacity of several hundred MW are feasible. Larger expanses and large solar capabilities are present in the region.

The city of Bukavu's energy condition has negative effects on the social, economic, and environmental fronts. Regarding the effect on the economic plan, let's mention the weakening of the economic fabric as well as the economic loss brought on by a lack of energy required for the sector's deployment. Low level of small and medium-sized business establishment in the production and processing of basic goods, which causes a population decline. With the development of fossil fuels, which cause the production of greenhouse gases that harm the environment and are the cause of climatic changes, the impact on the environment is amplified.

F. Potential of Solar Energy

As we noted in the introduction, the earth's surface gets 16.1015kWh annually (equal to one continuous power of 180. 106 GW), of which 45% is absorbed, converted to heat, and radiated as infrared. Of this amount, 30% is immediately reflected into space. The remaining 25%, or an average of 45.106 GW, feeds the hydrological cycles (24%) and photosynthesis (0.06%). The DRC is undoubtedly on the equator and is situated just below the solar belt, which explains why the solar potential is significant. The daily global radiation and sunshine (year average) in Bukavu are 4.60 kcal/m2 and 5.34 kWh/m2, respectively [9]. The DRC is in a very high band where the minimum requirement for electrification by photovoltaic system is 1 kWh/m^2 [10], whose measurements of sunshine were carried out in various meteorological stations across the nation. From this, we can infer that solar energy offers a tremendous untapped potential.

G. Solar Energy Usage

In Bukavu and even in peri-urban areas, solar energy (photovoltaic energy) is one of the families of renewable energies that is utilized domestically and non-industrially. According to our survey respondents, photovoltaic energy is still used by certain houses, churches, hospitals, schools, and other organizations for lights, laptops, televisions, and charging phone batteries. The electrical energy generated by photoelectric systems, which convert solar energy into chemical energy and then chemical energy into electrical energy, is stored in accumulators. A more comprehensive idea would be to feed the extra electricity into the current networks and use them to supplement solar energy when it is not enough. This prospect is nevertheless constrained by the project's expense and dependability. Businessmen import solar panels, however neither in the province in general nor in Bukavu specifically has a solar power plant been built yet.

Comparing our findings to the National Energy Commission's findings on energy consumption in cooking in the DRC in 2010, it turns out that 95% of the country's energy supply is provided by biomass, compared to 3% by electricity and 2% by petroleum products. The difference between our findings and those found in the city of Bukavu, where 97% of energy is provided by embers and firewood and 3% by electricity, is not particularly significant. According to the figure 3, solar energy is being embraced and used more frequently in the city of Bukavu, making up 7% of home consumption in 2016 compared to 2% in 2012. However, the current rate of growth in the share of solar in consumption is enormous, but let's not forget its primary drawback: it is only accessible during the day, which justifies the use of multiple energies in the home (three to four energies), as none of these energies fully meet household needs. Even while certain systems permit production a few hours after sundown, electrical storage is still insufficient to allow the sun to be utilized as the only source of electricity. As can be seen in the figure 2, solar energy is at 0% till that point for cooking. According to our findings, wood energy continues to be the primary source of energy for cooking, accounting for 97% of solid fuels (embers), up from 93% in 2012 as determined by B. Kajibwami [11]. Additionally, it is unlikely that solar energy will ever be used for transportation the primary source of air pollution at least not anytime soon.

However, as seen in the figure 4 , according to our surveys, photovoltaic energy is now a reality for the people of the city of Bukavu, with 40% of households there using either a solar panel or a solar lamp for one purpose or another. We can cite its qualities of being able to be installed anywhere (on the ground, on the roof, in the air, etc.), accessible to everyone easily movable and transportable, on-board and integrated into use to form a single element modular and there is not a single country in the world where we would not find no photovoltaic installations due to its great technical advantages, disregarding ecological and economical aspects.

H. Impacts of Solar Energy

The creation of power from renewable energy sources does not directly produce greenhouse gas emissions, as we indicated in the introduction. The usage of solar energy has a very low environmental impact because it practically never emits pollutants, which is one of its strongest points. The only sources of CO2 emissions associated with these technologies are the infrastructures that are built and maintained, which differ substantially from one location to another [12]. Contrary to some prevalent misconceptions, the environmental impact of using solar energy as a renewable energy source is very low but not zero.

According to the results analysis, fossil fuels continue to be the primary energy source for lighting Bukavu (32% vs. 46%, hydropower at 58% vs. 43%, solar energy at 17% vs. 7% for solar lamps in 2012 , and 40% of households use either a lamp or a solar panel for one or the other need in the home today. Taking into account these findings, the usage of diesel engines for the generation of electric current is gradually phased out, and solar energy adoption

is progressing. Maldague (2011) found that, compared to Karume (2009)'s findings, the DRC currently has one of the lowest energy consumption indicators in the world because of a lack of investment in new technology and rapid population growth. These factors together result in a strong dependence on fossil fuels (32%). 1.5% more oil is consumed at the provincial level, which can be attributed to the fact that city dwellers engage in a lot of electricity-dependent activity [13].

V. CONCLUSION

The DR Congo, in general, and the city of Bukavu in particular, have a ton of potential for renewable energy sources like solar, hydropower, biomass, and biofuels. We currently observe that there is a lot of confusion in the energy sector. While the demand for inadequate electrical energy rises as a result of the city of Bukavu's extremely rapid population development and the rural flight caused by the widespread insecurity in the South Kivu province. Despite all of these obstacles, the province has no solar power plants under construction.

We draw the following conclusions in light of the findings and discussion of the findings in this article: The consumption of energy for domestic needs, primarily for cooking food in households in the city of Bukavu, remains dominated by the use of embers, which is estimated to be 97% of the total. Electricity consumption is only 3% of total consumption, and solar energy is still absent, at 0%. Even while solar energy is currently growing at a tremendous rate for lighting, let's not forget that it is still too inefficient to be used as the primary source of electricity because it is only available during the day. Solar energy still has its limitations; for the foreseeable future, at least, it is not truly used for transportation, the primary source of air pollution. According to the study, peri-urban areas' surfaces could be used to build solar power plants, which could produce enough electricity to meet current demands and reduce electricity costs. This would relieve pressure on forests and other natural resources and have an effect on social and economic life.

The advantage of using renewable energy is that it does not produce greenhouse gas emissions directly. For example, using solar energy produces nearly little pollution, therefore its use has very little of an influence on the environment. The infrastructure's construction and upkeep, which differ widely from site to site, is the only factor contributing to the CO2 emissions associated with these technologies. Contrary to some prevalent misconceptions, the environmental impact of using solar energy as a renewable energy source is very little but not negligible. In order to achieve it as much as possible, it is essential to diversify the energy park through renewable energies. Benefits would include a decrease in reliance on fossil fuels and wood fuels, lessening the strain on the environment's resources, and enhancing the standard of living and health in rural areas. However, connecting to the power grid would be prohibitively expensive.

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