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SOLAR POWER ANALYZER: A PHYSICAL AND CYBER SYSTEM FOR SOLAR ENERGY COMPUTATION

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***ABSTRACT*:**The electricity requirements of the world are increasing at alarming rate and the power demand has been running ahead of supply. The major disadvantage of fossil fuels is environmental degradation .As CO2being a greenhouse gas is major cause of global warming. All this facts promote us to use renewable energy resources (Solar energy, Wind energy etc.).Amongst all, the most sustainable renewable resource is solar energy which is free, clean and inexhaustible. Solar panels are responsible for converting solar energy into electricity. The advantages of employing the photovoltaic cells include no production of pollutants during operation, silent, long lifetime and low maintenance. The only concern is unawareness about solar energy among individuals and the number of resources needed to produce electricity. Solar Power Analyzer estimates the number of solar panels required to generate sufficient electricity for a given place based on the users location .We calculate number of solar panels required for the given area. For a given location using the data provided by NASA Surface Meteorology and Solar Energy Website we find the amount of electricity generated and also display it graphically. The Solar Power Analyzer also helps customer to see the Sellers in nearby locality and provide the interface to contact with them.

Keywords: Solar, Solar Power, Insolation, Renewable Energy, Radiation, Meteorology

1. INTRODUCTION

Energy is the fundamental of life and movement in the universe and hence it forms the foundation of all our activities and other things that life depends upon like, food, electricity or development. The conventional resources of energy were natural, mostly non-renewable and they hardly needed any external assistance until man got technology and started to exploit these resources for variety of purposes. As these non-renewable resources like fossil fuels, forest, rivers have depleted and environmental concern has increased, renewable energy has become very important for the sustenance of life. With due concern from organisations working towards a better future and environmentalists many industries are now moving towards the renewable source of energy. One of the renewable sources of energy is Sun, which has made life possible on our planet by providing heat and light, both fundamental for existence. With the advancement of technology solar energy can be used for a variety of purposes of which generating electricity is a major one. This can be done either by directly using photovoltaic (PV) or indirectly by concentrated solar power, or a combination. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam which in turn can generate heat that can be used in a way with turbines to make electricity[1]. But on the other hand a very direct process that uses Photovoltaic cells to convert light into electric current using the photovoltaic effect is not only cheaper but can be used by individuals unlike turbines.

As the consumption of electricity is increasing not only in Industries but also in households, people should move towards the solar power from the electromechanical generators which uses coal and other non-renewable resources so the negative impact on environment can be reduced for sustainable life existence . According to a report by the International Energy Agency, the rise in amount of electricity produced from renewable sources increased from just over 13% in 2012 to 22% the following year[2]. But this growth is more in the industrial sector than the residential sector which uses a significant amount of electricity every day. This is because people think the solar panels would take a lot of terrace space which they don't have and can be much costly. And they are not able to estimate whether the amount of electricity generated by the solar panels will meet their requirements or not. Even the sellers of Solar panels are not fully informed and hence they cannot part useful information to the customers. Apart from this, around 60% population is not aware about the subsidiary provided by the government of India on solar panels installation[3] and lack in information about its technical compatibility for using space and generating power.

In order to make these details easily available and provide with proper guidance on installation and power generation, an application has been designed by our team. Solar Power Analyzer is an Android based application that runs on smartphones. It helps the customer to estimate how much electricity will be produced yearly and monthly depending upon the location of the Customer and it also tells how much space will be required by the solar panels and how many solar panels will be needed to meet the customer's need of electricity. With all this information the customer can easily come to a conclusion of what type of solar panel will be beneficial for them. The application interface is very user friendly and can be operated with a little effort giving customer the desired data instantly.

2.RELATED WORK

The most important factor responsible for calculating the electricity generated through solar power is the average solar irradiation incident on the PV panels. In this approach, average solar irradiation for a given location is extracted through existing solar data sets of National Renewable Energy Laboratory, or NASA's SSE, or using an API like WeatherAPI.This extracted data is then used as a parameter in the formulae available.

Some recent noteworthy works in calculating electricity from solar PV cells and extracting solar irradiation data is discussed. Michael Boxwell devised a formula to calculate energy generated depending upon the wattage of the solar plant[4]. ISRO's Space Applications Centre, Ahmadabad developed an app that provides solar energy potential at any given location[5]. It uses Indian Geostationary Satellite data (Kalpana-1, INSAT-3D and INSAT-3DR) for fetching monthly and yearly solar irradiance of the given location.It then displays graphs of insolation throughout the year,temperature,and sun path.Although the data was quite accurate,it was limited to only India.Furthermore,a drawback noticed was that the app wasn't easily readable by an average Joe. Website of MYSUN,an online rooftop solar company operating in multiple states in North,Central and Western India,provides a solar calculator which takes input the location and outputs the wattage of plant required,electricitygenerated,recommended area of installation and estimated cost of the plant. It also calculates the money saved if the plant is installed. It, however, isn't much flexible when it comes to adjusting user required area and wattage requirement[6,7].

3. PROPOSED METHODOLOGY

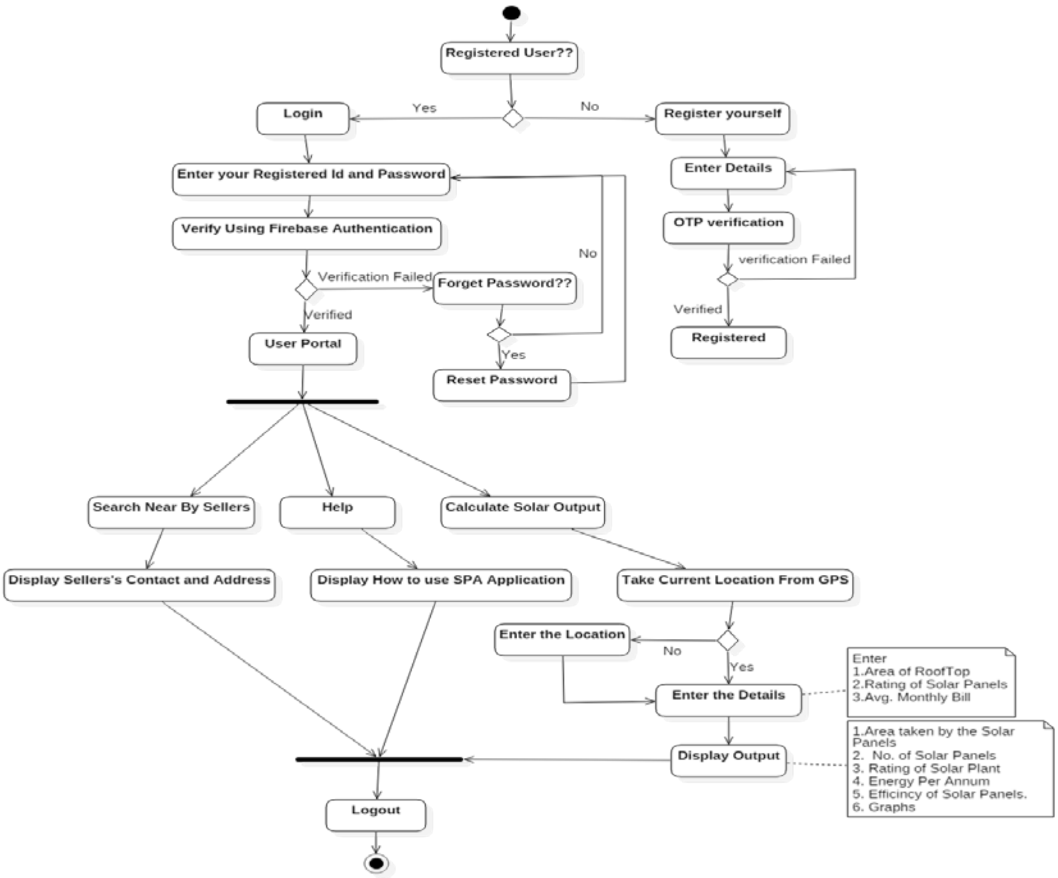

Figure 1.Methodology

After logging in the password verification is performed firebase database where the details of user are already stored.The whole methodology is shown in *Fig 1.*
.Successful login allows user to choose among the three options namely: search nearby sellers, help, Calculate.

- **Nearby seller:**

Here the user can view nearby sellers present near user's locality.

- **Help:**

The user can get help information for using the android application.

- **Calculate:**

In this, location where panels are to be installed is taken through GPS. The User has to provide input area, Rating of panels, average monthly bill .Using the latitude and longitude, NASA provide data considering various parameters like tilt angle, intensity etc. The output report is displayed which consist of Area by solar panels, Rating of solar panels, Energy per annum, efficiency of solar panels, Graphs.

After knowing these details the user logs out.

The calculation[8,9] uses the following formulas:

Number of solar panels = Area of installation / 17.6 (17.6 sq. ft. is the standard size of a solar panel)

Efficiency of Solar Panels = Panel Capacity / Panel Size

Energy per Annum = Area * Efficiency * H * PR

(H=Annual average solar radiation on tilted panels (shadings not included and taken from NASA's Site)
PR=Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75))

Insolation refers to the quantity of solar **Radiation** energy received on a surface of size X m² during an amount of time T. In the **photovoltaic industry** it is commonly expressed as **average irradiance** in kilowatt per square meter (kW/ m²) or – taking into account the time factor – kilowatt hours per year per kilowatt peak kWh/(kW_p*year).

Sample Calculation :

E = A x r x H x PR
A = 385 square foot = 35.76 m^2 (Area)
r = 13.5317% (Efficiency)
H = 6.60 (Solar Radiation) - (Ref. -2nd Table -1st Column)
PR = 0.85 (Performance Ratio)
Daylight = 11 (Ref. -4th Table - 1st Column)

E = (35.76 x 13.5317 x 6.60 x 0.85)/11
E = 246.7857 kWh
(Calculated for the month of January)
Some of the Data Tables from NASA Surface meteorology and Solar Energy[10]used are given below :

Table I :Minimum And Maximum Difference From Monthly Averaged Direct Normal Radiation (**%**)

Lat 21.177 Lon 79.062	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	-13	-14	-10	-7	-9	-50	-81	-58	-62	-12	-16	-39
Maximum	10	3	9	8	6	32	n/a	n/a	n/a	14	3	0

Table II :Monthly Averaged Radiation Incident On An Equator-Pointed Tilted Surface (kWh/m^2/day)

Lat 21.177 Lon 79.062	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direct	6.60	7.19	7.17	7.17	6.35	3.54	2.14	2.08	3.41	5.82	6.65	6.79

Table III : Monthly Averaged Insolation Incident On A Horizontal Surface At Indicated GMT Times (kW/m^2)

Lat 21.177 Lon 79.062	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average@00	0.00	0.00	0.01	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00
Average@03	0.23	0.28	0.35	0.43	0.44	0.33	0.24	0.23	0.30	0.35	0.31	0.26
Average@06	0.66	0.75	0.84	0.89	0.87	0.64	0.48	0.47	0.60	0.71	0.70	0.66
Average@09	0.54	0.64	0.69	0.71	0.66	0.49	0.42	0.41	0.46	0.53	0.50	0.49
Average@12	0.07	0.10	0.12	0.14	0.13	0.11	0.10	0.08	0.06	0.05	0.04	0.04
Average@15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Average@18	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Average@21	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table IV :Monthly Averaged Daylight Hours (hours)

Lat 21.177 Lon 79.062	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
22-year Average	11.0	11.4	12.0	12.6	13.1	13.4	13.2	12.8	12.2	11.6	11.1	10.8

4. FINDINGS AND RESULTS

Analysis of energy production is done on basis of historical data obtained from NASA's SSE Datasheet which provides required data for specified location co-ordinates. User gets a near to accurate energy production per month from the solar panels. Also Optimal tilt angle at which the solar panels prove to be most efficient are provided.

4.1 Code

Below is the code for scraping the NASA's SSE Datasheet

```
public class Scrape extends AppCompatActivity {

        @Override

protected void onCreate(Bundle savedInstanceState) {

super.onCreate(savedInstanceState);

asyn= new doit(latitude,longitude); //Latitude and Longitude taken from the user

asyn.execute();  }

public class doit extends AsyncTask<Void,Void,Void>{

            String words="";

            String lat,longi;

doit(String lat,Stringlongi)

{this.lat=lat;

this.longi=longi; }

@Override

protected void onPreExecute() {

super.onPreExecute();

dialog.show();

 }

@Override

protected Void doInBackground(Void... voids){

    String url1,url2,url;

  url1 = "https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?&num=100124&lat=";

url2="&hgt=100&submit=Submit&veg=17&sitelev=&email=

skip@larc.nasa.gov&p=swv_dwn&p=exp_dif&p=avg_dnr

&p=daylight&p=ret_tlt0&p=TSKIN&step=2&lon=";

url = url1 +lat+ url2 +longi;

Document doc = Jsoup.connect(url).get();

Element table,rows;

table = doc.select("table").get(2);

rows = table.select("tr").get(1); for(int i=1;i<=12;i++)

energy[i-1]=Double.parseDouble(rows.child(i).text());

table = doc.select("table").get(9);

rows = table.select("tr").get(1);

for(int i=1;i<=12;i++)

dayhour[i-1]=Double.parseDouble(rows.child(i).text());

table = doc.select("table").get(10);

rows = table.select("tr").get(11);

for(int i=1;i<=12;i++)

angle[i-1]=Double.parseDouble(rows.child(i).text());

table = doc.select("table").get(12);

rows = table.select("tr").get(1);

for(int i=1;i<=12;i++)

temp[i-1]=Double.parseDouble(rows.child(i).text());
```

User Input

1. Location Coordinates
2. Area of Rooftop

3. Installation Area
4. Rating of Solar Panel.
5. Avg. Monthly Bill

4.2 Output

1. Area takenby the Solar Panels
2. No. of Solar Panels
3. Rating of Solar Plant
4. Energy Per Annum
5. Efficiency of Solar Panels.

4.3 Graphs

1. Average Energy Production per month
2. Opt.Tilt Angle for Panels per Month
3. Hours Of Daylight per Month
4. Average Temperature per Month

A. Case 1:

Input:

Latitude	: 21.1770
Longitude	: 79.0618
Area of Roof Top	: 500 sq. ft.
Installation Area	: 400 sq. ft.
Rating of Solar Panel	: (220-250)W

Output:

Installation Area	: 385.0 sq. ft.
No. of Solar Panels	: 22 panels
Rating Of Solar Plant	: 4.84kW
Energy Per Annum	: 3209.9167 kWH
Efficiency Of Panels	: 13.5317%

Below Figures illustrate the output of Case 1 :

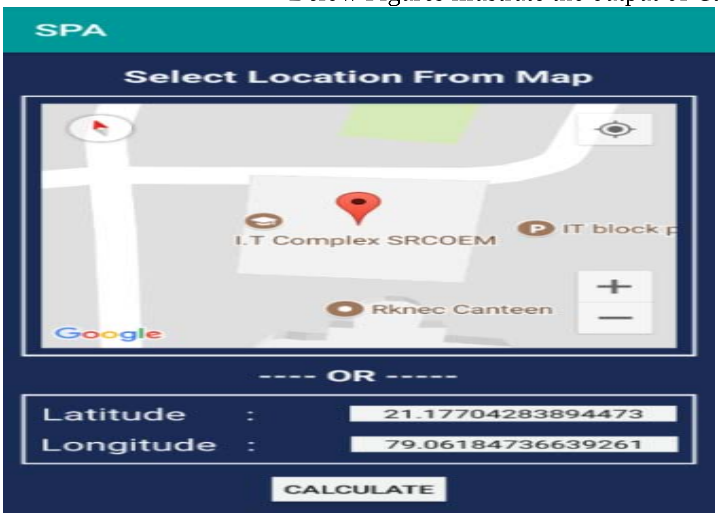

Figure2.Taking Location

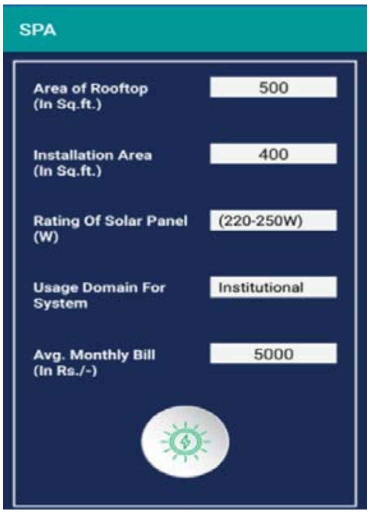

Figure 3. Output for Given Locality

Table V : Case 1 Output

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Energy(kWH)	248	266	333	351	353	257	209	199	228	275	249	241
Tilt Angle	46°	38°	24°	8°	0°	8°	5°	2°	14°	32°	45°	49°
Daylight (h)	11	11.4	12	12.6	13.1	13.5	13.4	12.7	12.3	11.6	11.2	10.7
Temp (°C)	23°C	27°C	33°C	38°C	40°C	33°C	28°C	26°C	27°C	26°C	24°C	22°C

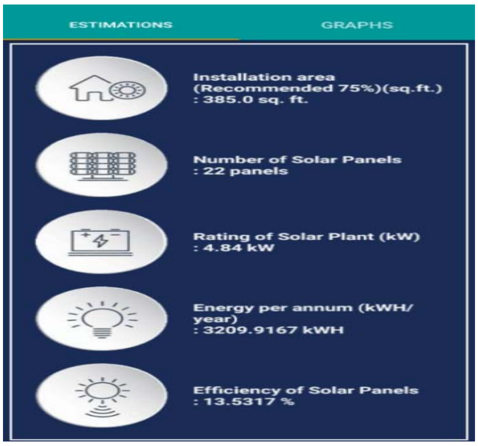

Figure 4. Estimated Output

Figure 5. Estimated Graphs

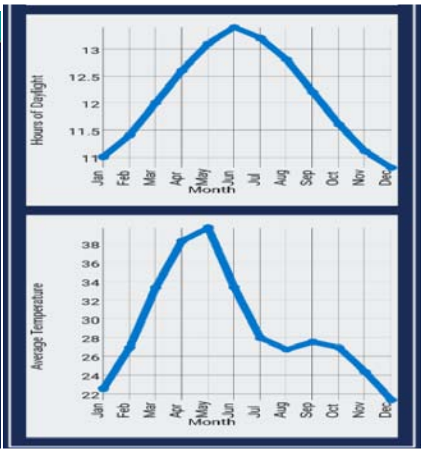

Figure 6. Estimated Graphs

B. Case 2:

Input:

Latitude	: 18.4950
Longitude	: 73.8535

Area of Roof Top	: 500 sq. ft.
Installation Area	: 400 sq. ft.

Below Figures illustrate the output of Case 2 :

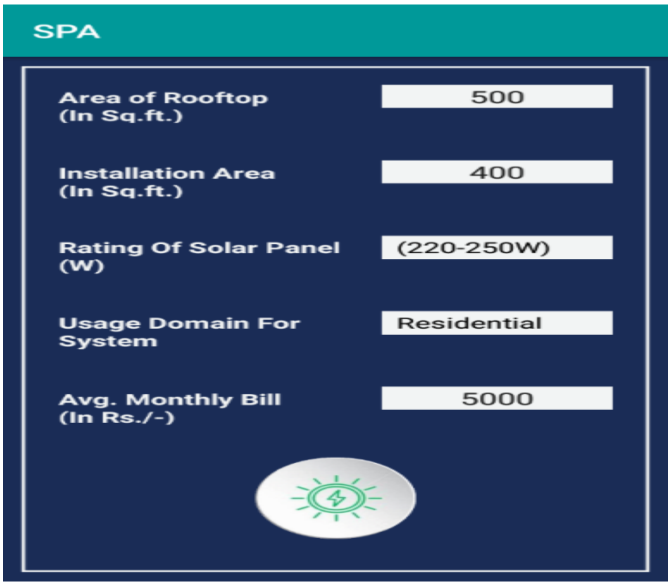

Figure 7.Taking Location

Figure 8. Output

Table VI : Case 2 Output

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Energy(kWH)	272	278	347	356	352	225	189	191	232	274	259	254
Tilt Angle	45°	35°	21°	5°	6°	8°	5°	1°	12°	29°	42°	48°
Daylight (h)	11.1	11.5	12	12.5	13	13.3	13.1	12.7	12.3	11.7	11.2	11
Temp (°C)	27°C	29°C	32°C	34°C	31°C	27°C	25°C	24°C	27°C	26°C	27°C	25°C

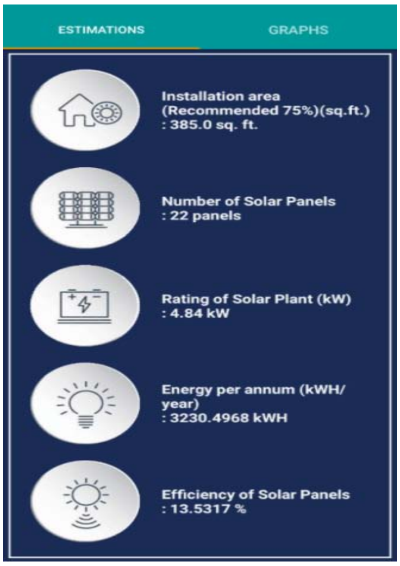

Figure9. Estimated Output

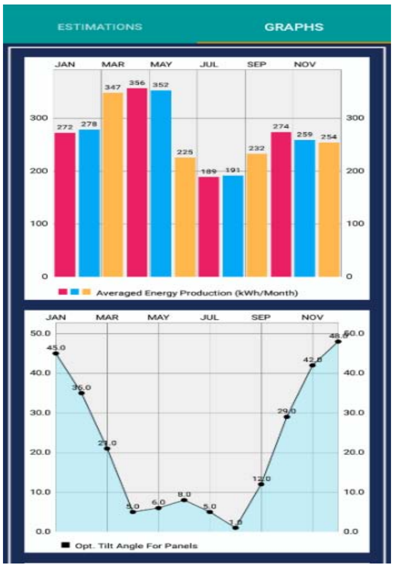

Figure10. Estimated Graphs

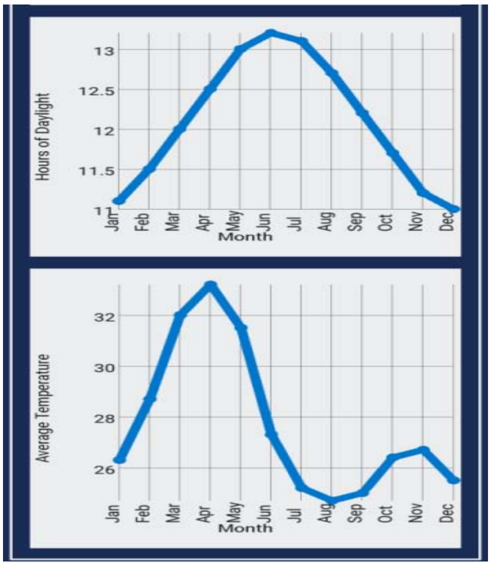

Figure11. Estimated Graphs

5. FUTURE SCOPE

The proposed approach can be used to calculate electricity generation from solar panels at any location over the globe with good accuracy. In our future work we will focus on predicting the electricity generation for next 7 days (including the current day).We will compare the difference of cost which the user pays while using electricity from plants to that of electricity from solar panels[11,12].

6. CONCLUSION

In this paper, we presented an approach to calculate number of solar panels required ,and electricity generated from the panels for a particular location.

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