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Intelligent Solar Panel Installation

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***Abstract*- As the demand of pollution free environment and free consumption of electricity is increasing day by day. So, photovoltaic and solar thermal panels are good medium for generating free electricity in a pollution free environment. Solar Panels are used in society. The users are not having sufficient knowledge for fitting solar panels at proper place or angle. Therefore, the development of an intelligent solar panel installation system is required. This paper focuses on the optimization of the energy production by photovoltaic cells, through placing solar panel on appropriate tilt according to the season with development of an intelligent solar panel installation system. The developed system is innovative in relation to the usual solar panel installation system available in the market. In fact, the developed solution has many advantages in relation to similar existing devices, as this system provides suitable angle with respect to city selected as well as it uses GPS for better results. The system uses Magnetic field sensor and Orientation sensor for placing Photovoltaic panel in appropriate direction and tilt. The system is intelligent in a way that it performs optimization of angle for a particular place for maximizing photovoltaic energy production. An experimental application was built and results have proven good performance of the developed installation system.**

***Keywords*—Photovoltaic Panel, Magnetic Field, Orientation Sensor.**

I. INTRODUCTION

With rise of population, there is an increasing demand for energy, which in turn results in continuous rise on the price of fossil combustibles. In fact, it is expected in the near future, that the demand for energy will grow faster than the finding out of new available fossil resources [2]. There is a need for finding an alternative source of energy. In this context we have focused on renewable energy. Out of these renewable energetic sources, the international scientific community has devoted intense efforts to wind, solar photovoltaic and biomass. In this paper an intelligent solar panel installation system for efficiency maximization referring photovoltaic energy production is developed.

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons by the photovoltaic effect.

Solar cells produce direct current electricity from sunlight which can be used to power equipment or to recharge a battery [1]. For best performance, terrestrial PV systems aim to maximize the time they face the sun. Solar trackers achieve this by moving PV panels to follow the sun. The increase can be by as much as 20% in winter and by as much as 50% in summer. Static mounted systems can be optimized by analysis of the sun path.

Panels are often set to latitude tilt, an angle equal to the latitude, but performance can be improved by adjusting the angle for summer or winter [2].

For maximum efficiency we require to track sun minute by minute by using an automated solar tracker. But, the expense of a tracker is more than buying additional panels to compensate. The amount of power, a solar tracker uses in order to track the sun also reduces the efficiency of the system. Therefore, it is urgent to improve the production efficiency of electricity from the Sun as this energetic source is the most powerful in our planet, and it is expected that the Sun will become the main electricity production source by the year 2100, according to the study presented by the German Advisory Council on Global Change [3].

We hereby focus on the optimization of the electric energy production by photovoltaic cells through the development of an intelligent solar installation system. The developed system is innovative in relation to the usual systems available in the market.

The usual available solutions for tracking systems rely on the tracking sun continuously and altering tilt of panel. The tracker itself requires power and thus reduces efficiency of the system. Other modern solutions for fixed panels require regular checking and altering of device which is done by an agent at a nominal cost.

The solution developed is to figure out the finest position and direction angle of a solar panel to capture maximum sunlight and give the optimal results all year round. As the correct angle of Photo-Voltaic panel depends upon the latitude and longitude or the place where you are installing the solar panel, so using the current GPS location or by manually feeding the required place, the application's algorithm would evaluate optimised angle for photovoltaic panel on which sunlight is maximum for a season. Also users can use this application manually to check the tilt and direction at regular intervals for maximised results. If the panel gets distorted due to any natural calamity user can correct itself without hiring an agent for the same. This would result saving money and time for end user. Also the system provides power estimation and evaluation for getting an estimate about the power that can be generated and the configuration of solar panel required to generate this power.

II. BACKGROUND

The average power loss in solar power generation is due to incorrect angle of solar panel is up to 25%. It is difficult to adjust the panel angle appropriately. This research paper focus to derive a method which gives the exact tilt of panel to produce maximum output. The paper contains the use cases and sample test cases under which the method get tested.

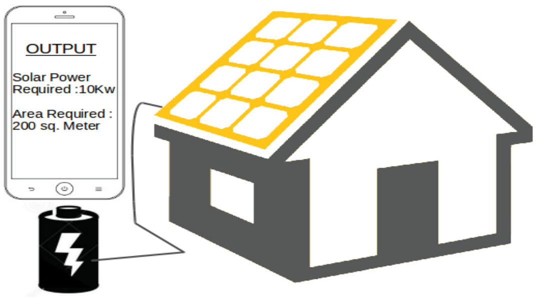

Figure. 1

III. Literature Surveys

Haixiang Zang [1] determined the optimal tilt angle of solar collectors for different climates of China. The paper suggested a simple and universal method to obtain the optimum tilt angles by estimating the monthly mean daily global solar radiation on tilted surfaces facing directly towards the equator, which is based on monthly average daily global solar radiation data produced from Typical Meteorological Year (TMY) data.
Rohit kamble [2] developed a solar mobile charger. This work is about using non-conventional energy i.e. solar energy for mobile battery charging. Solar chargers are simple, portable and ready to use devices which can be used by anyone especially in remote areas. Solar panels don't supply regulated voltage while batteries need so for charging. Hence, an external adjustable voltage regulator is used to have the desired constant voltage.
Suzit Kumar [3] developed a mathematical analysis to find out an optimum tilt angle of PV panel for Jaipur. This paper presented a method which combined more mathematical techniques to find out an exact and effective tilt angle for PV panel to produce more power. On the basis of mathematical calculation, the result showed that the seasonal optimum angle is 13°-22° for April month, 5°-10° for May month, 4°for June month,5°-10° for July month and 11°-22° for August month in the Jaipur area.
Kaveri Markam [4] did the estimation of optimal tilt angle for solar photovoltaic installations in India. Optimization of tilt angle ensures the maximum energy generation, thereby reducing the cost of power generation. This paper attempts to estimate the optimal tilt angle of PV for six different locations of India using various simulation software like RETSCREEN, PVSYST and NREL SAM. The simulated result shows that the majority of average solar radiation is above 5kWh/m2/d and falls in the range of 5-6.5kWh/m2/d. The yearly optimal angle obtained are having variation of +2° to +3° from the latitude of the location.
Osamede Asowata [5] developed Optimum Tilt Angles for Photovoltaic Panels during Winter Months in the Vaal Triangle, South Africa. The maximum output power of a photovoltaic panel depends on atmospheric conditions, such as (direct solar radiation, air pollution and cloud movements), load profile and the tilt and orientation angles. This paper describes an experimental analysis of maximizing output power of a photovoltaic panel, based on the use of existing equations of tilt angles derived from mathematical models and simulation packages.

Existing System

There are significant efforts on the optimization of sun tracking systems as it is documented by several registered international patents. The solutions are based either on the quantification of the received solar energy, either on the maximization of the solar incident radiation through the use of light concentration lens [5], [6]. There are similar applications available in Google's play store.
Sun Position Calculator Lite: This application is a sun angle calculator. Providing input as specific time, day, month, and location, it calculates sun elevation for you. It also uses Solar Position algorithm (SPA) library developed by National Renewable Energy.
Sun Navigation: It is another application which can find your position on earth from sun's elevation angle at solar noon. It manually calculates the latitude and longitude.
India is slowly gaining its prominence in the generation of solar power due to the comprehensive and ambitious state and the Centre's solar policies and projects and National Solar Mission. Solar energy is needed to fulfil the requirement of energy in India. The government having a large vision to expand solar technologies in the country. It is a market of Billions and our application helps to expand the solar technology in the market.
The application adds value to the solar services by providing a platform for both end users (household people) and suppliers.

IV. Proposed System

The proposed method of entire system is to install solar panel. Initial step is to know the specification of Solar Panel required to set up, for this we have **Power Mode** which is further divided as 1) Power Estimate 2) Load Evaluation.
Power Estimate: By monthly usage, and estimate hours of sunlight on average in a particular area as input, the amount of energy that could be produced is estimated.
This is evaluated as:
(Daily usage of power) / (k*Daily hours of sunlight)
Where k is constant and generally taken as 0.8
Load Evaluation: Setting up average usage of loads i.e. number of appliances, its usage in hrs on daily basis is used to estimate the total power consumption and number of hours of sunlight as input, the power generated by the solar panel is obtained.
This is evaluated as:
(Power Consumption) / (Daily hours of sunlight)
Here constant k is considered as 1
Next step is installation of Solar Panel which could be carried out either using **Quick Mode** or **GPS Mode**. Quick mode serve as a static mode which uses database provided by Green Stream publishing for estimating angle. It requires selecting city/state as input, and angles for three season summer, winter, and spring would be provided. On other hand GPS mode uses location as an input for evaluating the angle for the same. Using location we have latitude and longitude which are used as:
Summer tilt: ((latitude * 0.9) - 23.5),

Winter tilt: ((latitude * 0.9) + 29),
Spring tilt: (latitude - 2.5)
Further, the system provides magnetic compass for facing the panel in direction required. It uses magnetic field sensor of smartphones for estimating the direction. Once the panel is placed in direction specified next step is to set up the panel at required tilt, this is achieved by using orientation sensor of smartphones which when placed over the panel results the tilt of panel. It is demonstrated in the diagram below:

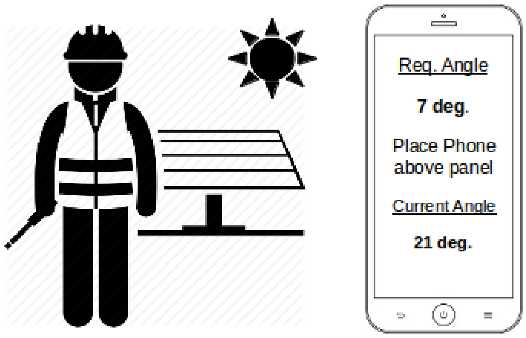

figure 2

V. Result and Discussion

LIGHTS	WATT	QUANTITY	HRS/DAY
LED LIGHTS	1	5	10
LED LIGHTS	3	3	8
LED LIGHTS	18	1	6
TUBE LIGHTS 2FT	30	5	5
TUBE LIGHTS 4FT	50	1	3

Table 1 (LOAD EVALUATION)

FANS	WATT	QUANTITY	HRS/DAY
CEILING FANS	130	6	12
AIR COOLERS	900	2	6
EXHAUST FANS	150	1	1
BRACKET FANS	110	0	0
PEDESTAL FANS	75	0	0

Table 2 (LOAD EVALUATION)

CITY	SUMME	WINTE	SPRIN	AVG.
	R	R	G	
ALLAHABAD	2°	48°	25°	25°
BENGALURU	10°	36°	13°	19.67°
CHENNAI	4°	44°	20°	22.67°
DELHI	6°	52°	29°	29°
GHAZIABAD	6°	52°	29°	29°
HYDERABAD	6°	40°	17°	21°
LUCKNOW	4°	50°	27°	27°
MUMBAI	4°	42°	19°	21.67°
NAGPUR	2°	44°	21°	22.37°
PATNA	2°	50°	26°	26°
UJJAIN	0°	46°	23°	23°
VISHAKHAPATNAM	6°	42°	18°	22°
YAMUNA NAGAR	6°	54°	30°	30°

Table 3 (QUICK MODE DATABASE)

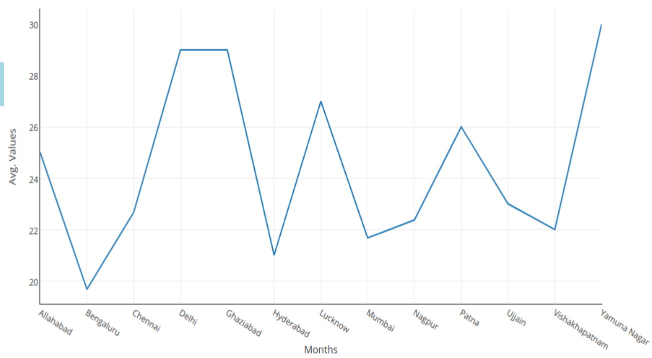

Fig. 3

The result includes following calculations:
The Global Positioning System (GPS) tracks the position of user through its latitude and longitude. The values of latitude and longitude are used to calculate the angle of tilt in different seasons. The mathematical expressions used are:

Summer tilt: ((latitude * 0.9) - 23.5),
Winter tilt: ((latitude * 0.9) + 29),
Spring tilt: (latitude - 2.5)
And average tilt can be calculated by:
Average tilt = (summer tilt + winter tilt + spring tilt) / 3

For evaluating the load, the user needs to select the load that he wants to run on Solar Panel. Once the loads are selected by the user, then the total power consumption is evaluated by:

Total Power Consumption in WATTS = watts * quantity * hours/day
And finally the power output is evaluated by:
Power Output of Solar Panel = Total Power consumption in watts / Total Hours of Sunshine
Our Country India lies in the northern hemisphere. Therefore when the sun travels, it creates an elliptical trajectory moving from east to west and having an inclination in south. Hence to get the maximum quantity of solar energy, panels in India face towards south.

Mobile sensors that android use to determine the position are geomagnetic field sensor and the accelerometer. The geomagnetic field sensor and accelerometer return multidimensional arrays of sensor values for each sensor event. The geomagnetic field sensor provides geomagnetic field strength values for each of the three coordinate axes during a single sensor event. Likewise, the accelerometer sensor measures the acceleration applied to the device during a sensor event. Our application uses one of these sensor values to adjust the solar panel and to bring it to a correct angle just by keeping the mobile device onto the panel.

Conclusion

The available applications/systems either provide the calculation of angle through latitude and longitude by tracking the location or an interface to provide angle for a particular area using database. Using smartphones to adjust the angle/tilt of panel and placing in direction required makes installation easier for end user. Every feature is provided under a single application to increase cost effectiveness, and use of renewable energy.
Installation system facilitates solar panel installers to configure solar panel tilt using smart mobile phones. It provides solar panel power output according to user's household needs. It also helps in establishing a marketplace to buy the solar equipment needed by any user. It provides a platform to local vendors of solar equipment's to expand their business easily and help them to connect the existing users as well. It is a complete solar guide for a user to install solar panel at their place. The application has a better User Interface which makes it user-friendly. It also provides a platform for Solar Investors like Government Bodies etc. to invest in solar technology and helps to manage and distribute the energy obtain by this system. It provides complete transparency to the user taking services by any energy provider.

Future Scope

The future goals is to establish a system which automatically calibrate the solar power system for maximum generation of output.

The goal to obtain a solution at a viable cost and develop devices which integrate with the panel and can be operate remotely.

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