

Implementing an Energy Calculator in a Mobile Based Application for Solar Potential Measurement

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Abstract

Solar photovoltaic (PV) technology has matured to become a technically viable large scale source of sustainable energy. Understanding the rooftop PV potential is critical for utility planning, accommodating grid capacity, deploying financing schemes and formulating future adaptive energy policies. The NIWE (National Institute of Wind Energy) under MNRE (Ministry of New and Renewable Energy) is an esteemed institute dedicated to Indian wind and solar renewable energy generation and monitoring. The SRRA (Solar Radiation and Resource Assessment) is a division under NIWE that is responsible for solar energy monitoring throughout India. They have created the Solar Radiation Map of India using high quality, ground measured solar data. This asks the question, whether it is possible to get a quick estimate of a solar installation. Thus, the paper explains the problems in the field of solar potential measurement and the deployment of a calculator in a mobile front platform. The mobile app would quickly and effortlessly give a rough estimate on what a solar installation could save in power consumption costs.

Keywords: Android app, solar calculator, GHI, google maps, NIWE, SRRA, GPS and Solar Atlas.

1. Introduction

The task of solar potential measurement is one that is taken by almost all Renewable Energy institutions across the globe. This field of calculating the estimate cost of installation and cost of energy generated over a period of time is an ever-evolving subject. There are various methods to calculate, but the right method involves use of high quality data about GHI (Global Horizontal Irradiance) of an area. The pre-existing work in this field primarily includes websites by different organizations like the US Department of Energy's PV Watts, Ministry of New and Renewable Energy India's SPIN and other privately-owned sites. The mobile based platform tends to simplify the process of getting an estimate by using latest technologies in mapping, data collection and visualizing data. This paper analyses the various platforms available today to get an estimate and the methodology and tools available to make it in the mobile platform.

2. Related Works

PV watts NREL website

The field of solar potential measurement is being predominantly done by a website named PV Watts under NREL (National

Renewable Energy Laboratory) US department of Energy. This website aims to provide data about the entire world on solar power plant cost estimation and energy production levels. This site uses the closest TMY (Typical Meteorological Year) weather data. This is hourly data developed using weather-satellite measurements incorporated into a site-time specific model. The Calculator estimates the electricity production of a grid-connected roof- or ground-mounted crystalline silicon photovoltaic (PV) system based on a few simple inputs [10].

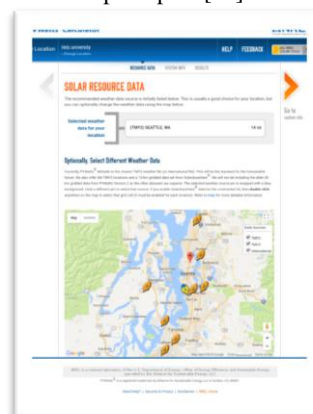


Fig. 1: PV Watts's website

Fig: 1 PV Watts site allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of a potential PV installation. This site allows to change the DC system size, module type, array type, system losses, tilt and azimuth values for a better estimate. However, this website is not very precise for India as solar data is best measured on the ground which is only available from SRRA department under NIWE for India. Also, the data provided by NREL is for a 10km x 10km grid which can be inaccurate for very small solar installations.

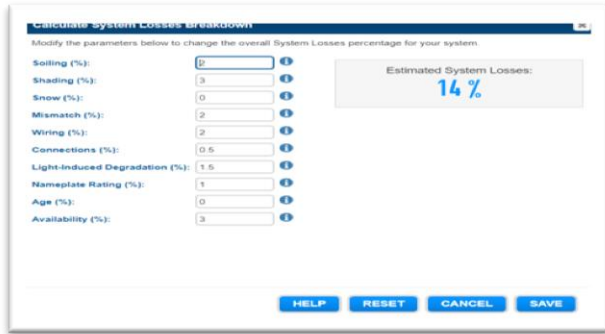


Fig. 2: System loss calculator

Fig:2 The loss calculator generates the estimated system loss based on different parameters about the installation and maintenance of the plant.

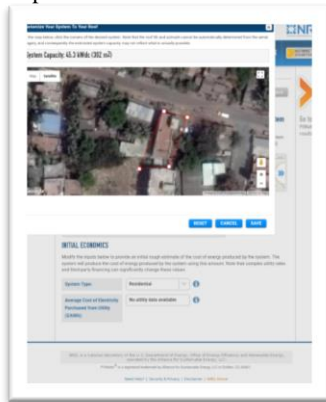


Fig. 3: Google maps area calculator

Fig:3 The website uses Google maps to measure area of a rooftop or an open area which is an accurate measure of area. Since Google maps is the most used type of commercial maps, it is familiar and easy to use.

The website uses the solar data from their closest source and location services from the Google maps to calculate energy generate by a PV system in $kwh/m^2/year$ and give a rough estimate of the cost of energy produced by the system. It is presented in US Dollars or Indian Rupees for every month and for the whole year. The site also allows us to set the tariff rates and determine the economics of a solar installation [3].

Month	Solar Radiation ($kWh / m^2 / day$)	AC Energy (kWh)	Energy Value ($₹$)
January	3.90	1,954	216
February	4.91	2,176	240
March	5.87	2,817	311
April	6.62	3,058	338
May	6.29	2,971	328
June	6.80	2,968	328
July	7.19	3,124	345
August	7.25	3,196	353
September	7.27	3,168	350
October	6.07	2,828	313
November	4.78	2,216	245
December	4.03	2,005	222
Annual	5.93	32,481	₹ 3,589

Fig. 4: Results page

Fig:4 The estimate given by the website is for every month with the average energy produced and the average cost of the energy produced. The total of the energy produced along with the total cost is also presented at the end of the screen.

The end result could be downloaded in a CSV format and be viewed in MS Excel. The monthly and hourly report could also be generated, which may be used in advanced plant design planning.

Solar rooftop calculator

The Solar Rooftop calculator is a solar calculator under the SPIN (Solar Photovoltaic Installation) website by the Ministry of New and Renewable Energy India [5]. It can take in values from the user as text and calculates the following values.

1. Size of the plant
2. Cost of the plant
3. Total Electricity Generation from the plant in 25 years
4. Financial Savings
5. Carbon dioxide Emissions Mitigated
6. No. of Trees equivalent
7. EMI Calculation



Fig. 5: Ministry of new and renewable energy’s SPIN (solar photovoltaic installation)

Fig:5 This is a basic website under MNRE that gives an estimate for grid connected rooftop solar installations in India. However, this does not make use of the latest maps technology. The result generated is of PDF form. It does not give any graph nor any monthly statistics to support its estimate.

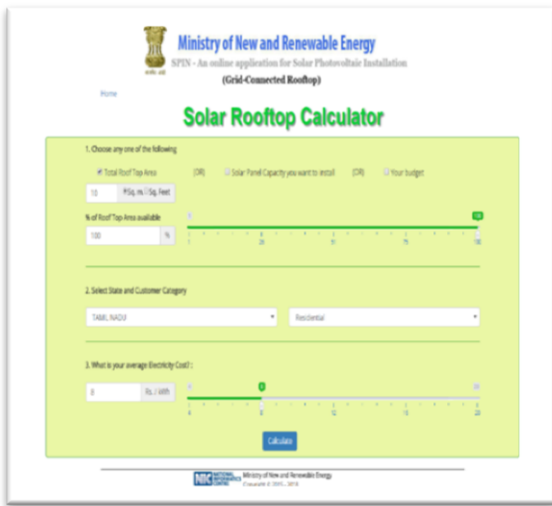


Fig. 6: Solar rooftop calculator

Fig:6 The website takes in Area of the installation (or) Capacity of the power plant (or) Budget, as the method of calculation, the state in which the installation is to be done as location data and tariff rates as input to the calculator. This method requires the user to know the area of the installation in advance if rooftop area method is used.

This website creates an estimate based on the assumptions that 10m² of solar panel area will generate 1kwh of power and 1kWp solar rooftop plant will generate on an average over the year 5.0 kWh of electricity per day (considering 5.5 sunshine hours). The plant capacity is calculated for area of rooftop method using the first assumption, for the capacity method the direct input of capacity is used and for the budget method the cost of the overall installation is considered. The total energy generation from the solar power plant is calculated using the assumption the solar irradiance of an entire state in India to be a particular value. For example, the solar irradiance value of Tamil Nadu is 1266.52 W / m².

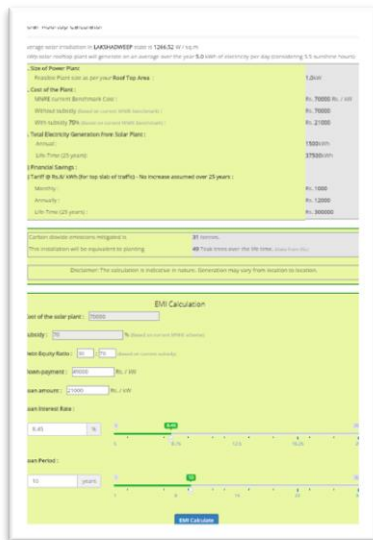


Fig. 7: SPIN's result page

Fig:7 This is a simple result page showing the calculated solar plant installation. It has a section that does EMI calculation for the same. The main disadvantage is that there is only one solar irradiance data for each state.

Solar Radiation Atlas

The Solar Radiation Atlas given by the SRRA department under NIWE website provides solar data with a 3km X 3km spatial resolution with an annual average value of

1. GHI (Global Horizontal Irradiance)
2. DHI (Diffuse Horizontal Irradiance)
3. DNI (Direct Normal Irradiance)

These are administrative details pertaining to the 3 km X 3 km grid. Here the values to GHI is sufficient to calculate the potential because the GHI is a combination of DHI and DNI given by the formula:

$$GHI = DHI + DNI * \cos(\theta)$$

This website also displays AEP (Annual Energy Production), CUF (Capacity Utilization Factor) and location of all the solar power measurement stations present across India [4].



Fig. 8: Solar radiation atlas

Fig:8 This is the Solar Radiation Atlas of India giving the annual ground measured GHI, DNI and DHI data from SRRA.

This method of displaying solar data is only useful for a large area solar panel construction in the category of MWH. However, for a home setup or for a smaller area we need more precise calculation of area, solar data and power potential.

Also, there is an android app available that uses text data of GHI, DHI and DNI from NIWE and uses google maps as its base map. This app is a basic reproduction of the already available solar atlas using Google map Android API. The app does not make any kind of prediction or analysis for the area to be deployed. The app to be made makes use of Android platform, google maps and the annual GHI data from the Solar Atlas.

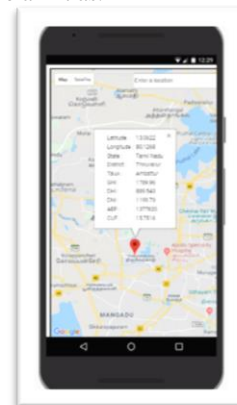


Fig. 9: Android implementation of the solar atlas

Fig:9 The app tries to reproduce the solar atlas and display nothing but basic data from the map. The app demonstrates the ability to use Android platform especially the Google maps Android API. The app's main disadvantage is that this app does not make any prediction on the solar potential for a given area nor give any cost benefit analysis.

3. Materials and Methods

The mobile app implementation of the solar calculator can be created using the android platform which is free and an open platform built on Linux. It is an open source solution for mobile devices offering a complete software stack including operating system, middleware, and key mobile applications [1]. The key advantages include speed, scalability, performance, customisable user interface and easy to adopt development techniques.

The first step to solar potential measurement is based on the location and the area to be deployed. The calculation of the area is done using the Google maps services [2]. The Google maps Android API is used to create map services on an android device. This service is free up to 25,000 users per day. One could use the GPS in their mobile device to locate themselves on the Google map easily [6]. We are using the following libraries under the Google maps API –

- The places library to automatically search for different places.
- The drawing library to draw shapes on top of buildings.
- The geometry library to measure area and distance.



Fig. 10: Google maps area measurement

Fig:10 The area measurement tool in the Google maps Android API is very accurate and precise for calculations all over the world. The area is calculated in m^2 and the satellite map type of the Google maps can be used to place the marker exactly on the rooftop. The output from the map service is an integer value of the available rooftop area with a location data (latitude and longitude) pinned to it.

The second step involves the app to use the location data from the map to fetch GHI value from the Solar Atlas of India made available by SRRA [8]. Using these values of area and GHI, the Power plant capacity, AEP (Annual Energy Production), CUF (Capacity Utilization Factor) and total energy production for 25 years (lifetime of the plant) with a degradation factor could be calculated [9].

The third step involves the fetching of confidential monthly data from a CSV file given by SRRA. It is of 33.3MB with more the 2 lakh individual rows representing each 3km X 3km grid point within India and 14 columns for 12 months and 2 for latitude and longitude. This data can be fetched using SQLite, an android based database platform [7]. This data would then be used to calculate the monthly power generation and the cost of the energy generated for every month.

A graph for representing the monthly GHI along with the amount of power generated and another for the cost of the energy generated will be displayed in the app for a clear representation of the benefits of the solar power.

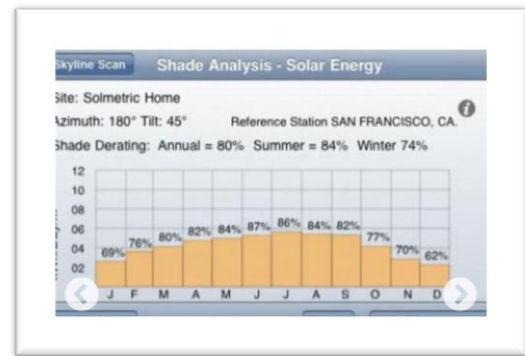


Fig. 11: Graph generation for monthly data

Fig:11 The app will show a similar graph with the month vs solar irradiance (GHI) and month vs energy generated and another for month vs cost of the energy generated.

This app would provide a clear advantage over the existing systems as it could easily use the best of them in a mobile application. The best Google maps services along with high quality SRRA sourced solar data and latest android-based visualization techniques are used. The app would finally allow the user to share his/her results in a PDF format or as CSV file format.

4. Conclusion

The novelty of the app lies in the fact that this platform is ever more mobile and portable. The ability to calculate the solar potential from a mobile device increases the chances for a person to prefer solar energy. The project thus proposed is an application of the opportunistic mobile application technology by being able to provide solar potential of any given area and quickly make a rough estimate on what is feasible for that area. The app also aims to implement the latest android features for easy use and management.

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