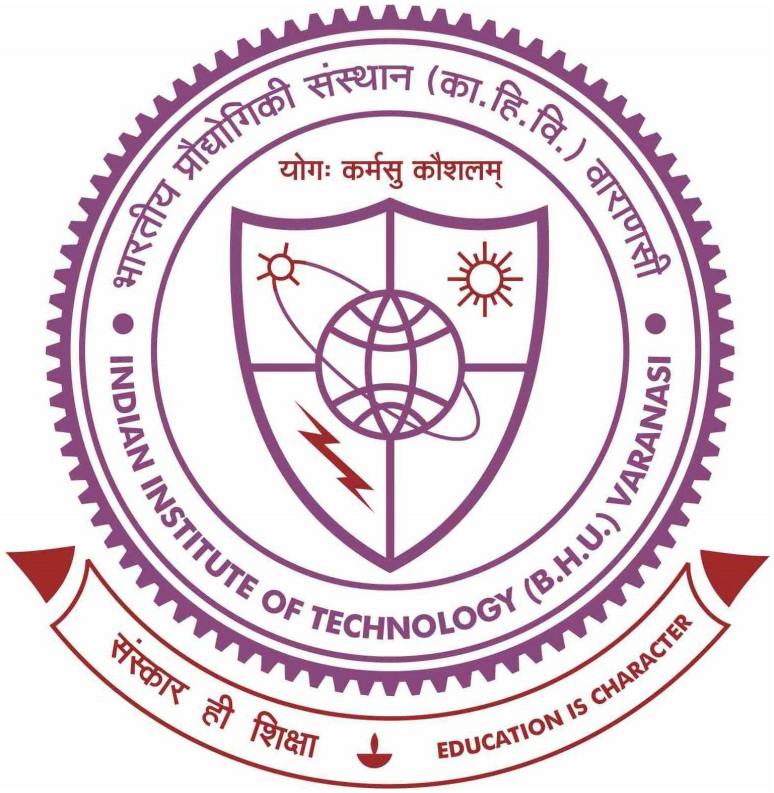
PROJECT
SOLAR SUNROOF



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Thank You.

Abstract

Our project aims to encourage the private adoption of solar energy by providing a set of tools to facilitate the purchase and installation of solar panels. The aim was to develop an algorithm which could predict the solar potential of a roof based on the location of the building,area of the rooftop and cost per unit of electricity in that area. We deployed this algorithm to develop a web app which calculates how much money a user can expect to save yearly by making use of solar power and also they will get to know the installation cost, savings per year and year required to get the return from the investment. As the price of installing solar panel has gotten less expensive, more homeowners are turning to it as a possible option for decreasing their energy bill. We want to make installing solar panels easy and understandable for anyone.

Report

Introduction

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. With the advent of time, their is the increase in the prices of the conventional electricity sources, hence we are likely to shift towards solar energy as a source of electricity production.The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. With the decrease in price of installation of solar panels and continuous increase in price of conventional energy sources, the time has come to switch to solar panel.

The sooner you adopt solar, the sooner you start saving. Solar power became cheaper than electricity in 2012. It is 30-70% cheaper than electricity now. If you haven't got solar yet, you are missing out on savings you can avail of right now. Every rupee saved is a rupee earned. Electricity prices rose about 7-8% yearly over the last 7 years.
Our math shows that purchasing a solar system on EMI is more financially prudent than not going solar.

Several benefits of the solar energy are :-

- Reduce air pollution.
- Cut global warming emissions.
- Create new jobs and industries
- Diversify our power supply.

Motivation behind this project

Every country has started going in the path of sustainable energy so as to decrease carbon content and pollution in the atmosphere. Our country is lacking behind in this perspective and this is not because of the lack of technology but lack of awareness, hence we have developed a web app

which will predict the solar potential of the roof of the building. We are motivated towards calculating the amount of money that an individual can save by using solar power as the source of their energy. With the cost of electricity always on the rise and the cost of solar panels more affordable than ever, it's easy to consider going solar. The good news is, solar panels can be installed on most any roof, regardless of the location, type of roof and pitch.

Background knowledge

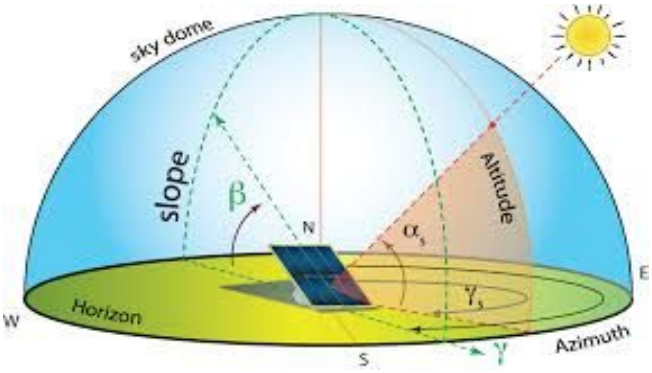
Solar irradiation falling on the surface of the earth can be further categorized in the following forms namely:-

- **Total Solar Irradiance** (TSI) is a measure of the solar power over all wavelengths per unit area incident on the Earth's upper atmosphere. It is measured perpendicular to the incoming sunlight. The solar constant is a conventional measure of mean TSI at a distance of one astronomical unit (AU). It is the amount of sunlight falling constituting all types of form including diffuse, scattered and reflected radiation. In this way this type of radiation becomes of prime importance for us.
- **Direct Normal Irradiance** (DNI), or *beam radiation*, is measured at the surface of the Earth at a given location with a surface element perpendicular to the Sun. It excludes diffuse solar radiation (radiation that is scattered or reflected by atmospheric components). Direct irradiance is equal to the extraterrestrial irradiance above the atmosphere minus the atmospheric losses

due to absorption and scattering. Losses depend on time of day (length of light's path through the atmosphere depending on the solar elevation angle), cloud cover, moisture content and other contents. The irradiance above the atmosphere also varies with time of year (because the distance to the sun varies), although this effect is generally less significant compared to the effect of losses on DNI.

- **Diffuse Horizontal Irradiance** (DHI), or *Diffuse Sky Radiation* is the radiation at the Earth's surface from light scattered by the atmosphere. It is measured on a horizontal surface with radiation coming from all points in the sky excluding *circumsolar radiation* (radiation coming from the sun disk). There would be almost no DHI in the absence of atmosphere.
- **Global Horizontal Irradiance** (GHI) is the total irradiance from the sun on a horizontal surface on Earth. It is the sum of direct irradiance (after accounting for the solar zenith angle of the sun *z*) and diffuse horizontal irradiance:

With the help of azimuthal angle and altitude we can define the position of sun at any time.



We also need to know the optimum angle of solar panel so that it can extract maximum energy from the sun.

The conventional wisdom(in the Northern Hemisphere) is that the best direction to face solar panels is south, since that is generally where they'd receive the most sunlight. However the electricity is not simple as it sometimes seen and the best direction to face solar panels may actually be west. Because of lower silicon purity, polycrystalline solar panels are not quite as efficient as monocrystalline solar panels, so we suggest using that only.

Methodology

The aim of the project was to calculate the solar potential of the roof. The meaning of solar potential is the amount of energy falling on the surface of roofs of buildings. We developed a web app which takes the input of current location of the building , area of the rooftop , and cost per unit of electricity supplied in that building by conventional energy sources and gives the output of installation cost for solar panels, profit generated per year by installation and the number of years to recover the installation cost.

We started this project by reading various research paper related to work in the field of solar energy and solar potential calculations. We found out that solar potential of a roof depends upon direct radiation , diffuse radiation, reflected radiation, optimum tilt of the solar panel and the area of the roof. We started our work by collecting data of variation of optimum angle of tilt and total irradiation at that optimum angle with latitude and longitude. The total irradiation at that optimum angle was calculated by taking the average of values of direct normal irradiance and diffuse irradiance over one year. We collected the data of irradiation and optimum angle from link[1]. After we collected the data and stored it a csv file. Then we used this data to train

our machine learning model which will predict the optimum angle and irradiation at that optimum angle.

We used different algorithms to train our model like support vector regression, linear regression, neural networks and random forest. We found that the best accuracy was obtained by random forest model. It is because in this algorithm we divide our data set in different sub samples and apply decision tree algorithm on each sub sample and then take the average of predictions of those sub samples and take the mean of them to reach our final prediction. This ensures that our model is not overfitted and also incorporates different features with great accuracy. The accuracy of this model was the highest hence we chose this model to train the data.

Then we used the predictions of energy output to calculate profit generated per year by installing the solar panel and hence the number of year required to get the return from the investment from installation of solar panel.

In India generally the efficiency of solar panel is between 13 % to 21% which gradually depreciates over the years.

Efficiency(t)=efficiency(initial) * (1-exp(-kt))

So we found out that the average efficiency over 15 years is around 15%, so we have taken this value to calculate the energy output of our solar panel.We tried to find the cost of installation of solar panel of 200W and finally found that it was around 15000 INR averaged over three states namely Bihar,Jharkhand,Uttar Pradesh. 200W solar panel implies that 0.2KWh(0.2unit) energy is generated by that solar panel per hour hence multiplied that with 365 times 6 hours(since maximum sunlight efficiency is

obtained during 9 to 3) will give us the output energy of that solar panel which is finally used to calculate our savings as the energy output times cost per unit in that building/locality gives us the savings.Total installation cost is given by the cost of installation times area of the roof covered by solar panel. We assumed that we can cover the 60% area of our roof with the solar panel cause other areas are covered by shades and other hindrance. After that we calculated the year of return from investment by dividing the total installation cost by total savings in a year.

We made a web application which takes the user input of location of building, area of the rooftop and cost of one unit of energy . It gives the output of installation cost, savings per year and year required to get the return from the investment.

We have got a lot of experience while doing this project and faced some challenges which we finally overcame during our project. We started this project from scratch and devised a blueprint to complete this project. We faced difficulties in data collection and deciding which algorithm to use.

We approached different hostels to know there average annual energy consumption and the energy produced by the solar panels installed on their rooftop.

Example of one data set is given below :-

A1 Hostel Name

	A	B	C	D	E	F
1	Hostel Name	Latitude	Longitude	Optimal angle	energy(in Kwh/m^2*year)	
2	s Ramanujan	25.26339	82.98477	27	323.5725	
3	S n Bose	25.263441	82.984003	27	323.025	
4	Aryabhatta	25.264239	82.984155	27	323.025	
5	Visweswariya	25.262318	82.983951	27	323.5725	
6	Department of Civil En	25.262839	82.991912	27	323.5725	
7	Computer Centre	25.263049	82.993388	27	323.025	
8	BHU trauma Centre	25.275813	83.006221	27	323.025	
9	institute of biomedical	25.452258	78.609762	29	330.69	
10	gandhi auditorium bun	25.453869	78.610119	29	330.1425	
11	Guest house bundelkha	25.455339	78.609692	29	330.69	
12	mahila maha vidyalaya	25.276722	83.002416	27	323.025	
13	Faculty Guest House	25.276449	82.990191	27	323.025	
14	Sun international scho	25.448753	78.596434	29	330.85	
15	Sunbeam School Lahar	25.316614	82.976032	27	314.526	
16	PG girls hostel bundelk	25.4558	78.607681	29	330.69	
17	likhdhari family guest h	25.44321	78.576359	29	331.785	
18	Jhansi jail	25.441991	78.573518	29	330.69	
19	christ the king college j	25.440763	78.568742	29	330.69	
20	St Jude shrine	25.44209	78.566793	29	330.69	
21	sfc	25.440241	78.561091	29	330.69	
22	Cathedral school	25.4402	78.542189	29	330.69	
23	Post office jhansi	25.426848	78.599971	29	330.69	
24	Mughalsarai Police chc	25.285357	83.115008	27	323.5725	
25	Allahabad	25.432298	81.757352	28	324.12	
26	iiit allahabad administr	25.43065	81.770845	28	324.12	
27	C/80, Patrkarpuram, Bh	25.350601	82.973068	27	322.475	
28	allahabad park	25.43224	81.857597	28	324.12	
29	outer allahabad	25.5298	81.856602	28	324.12	
30	Railway quarter gorakh	26.75436	83.3913	28	308.79	
31	Icici bank lakhimpur	27.948142	80.782313	29	315.9075	
32	outskrists of lakhimpur	27.981231	80.786187	29	315.9075	

Dependencies used for training data

- Pandas
- Sklearn
- Numpy
- Ensemble(Random Forest regression)

As it is visible that we have mapped buildings of cities of three different states namely Uttar pradesh, Bihar and Jharkhand, so our model can

predict the solar potential of roof of three different states with high accuracy.

Solar_Sunroof.py

```
import pandas as pd
import numpy as np
#from xgboost import XGBRegressor
from sklearn.ensemble import RandomForestRegressor

data = pd.read_csv('Solar Sunroof angle.csv')

X_train =data.iloc[:,1:3]
y_train =data.iloc[:,3]
X_train.head()

rdf=RandomForestRegressor(n_estimators=10,random_state=43,max_depth=3)
rdf.fit(X_train,y_train)
print(rdf.feature_importances_)
data2 =pd.read_csv('Solar test.csv')
X_test =data2.iloc[:,1:3]
prediction_1 = rdf.predict(X_test)
prediction_1
prediction_1=prediction_1.round()
data2['angle']=prediction_1
data2.to_csv('Solar_energy_test.csv')

data_1=pd.read_csv('Solar Sunroof energy.csv')

X_train1=data_1.iloc[:,1:4]
y_train1=data_1.iloc[:,4]
y_train1.head()

rdf1=RandomForestRegressor(n_estimators=10,random_state=43,max_depth=5)
rdf1.fit(X_train1,y_train1)
print(rdf1.feature_importances_)

data3 =pd.read_csv('Solar_energy_test.csv')
X_test =data3.iloc[:1,2:5]
X_test

prediction2 = rdf1.predict(X_test)
prediction2

def installation_cost_and_yeartorecover(area,cost_per_msquare,energy_output,cost_per_unit):
    installation_cost=0.6*area*cost_per_msquare
    profit_per_year=0.6*area*energy_output*cost_per_unit
    years_to_recover=cost_per_msquare/(energy_output*cost_per_unit)
    return installation_cost,years_to_recover[0],profit_per_year[0]

area=float(input())
cost_per_msquare=15000.0                              #for 200 W solar panel
energy_output=prediction2
cost_per_unit=float(input())

installation_cost_and_yeartorecover(area,cost_per_msquare,energy_output,cost_per_unit)
#The conventional wisdom (in the Northern Hemisphere) is that the best direction to face solar panels is
```

Image of the code

Outcomes of our project

- Developed an algorithm which predicts the solar potential of the roof.
- An online platform where anyone can come to see the solar potential of their house and get the financial details of installing solar panels on their rooftop.

Drawbacks of Solar energy

- The major drawback of solar energy is that it can be only produced significantly during day time and the energy stored can be used in the night.
- If the power consumption of the house increases then we have to again increase in the number of solar panels that are installed.

Impact on Common People

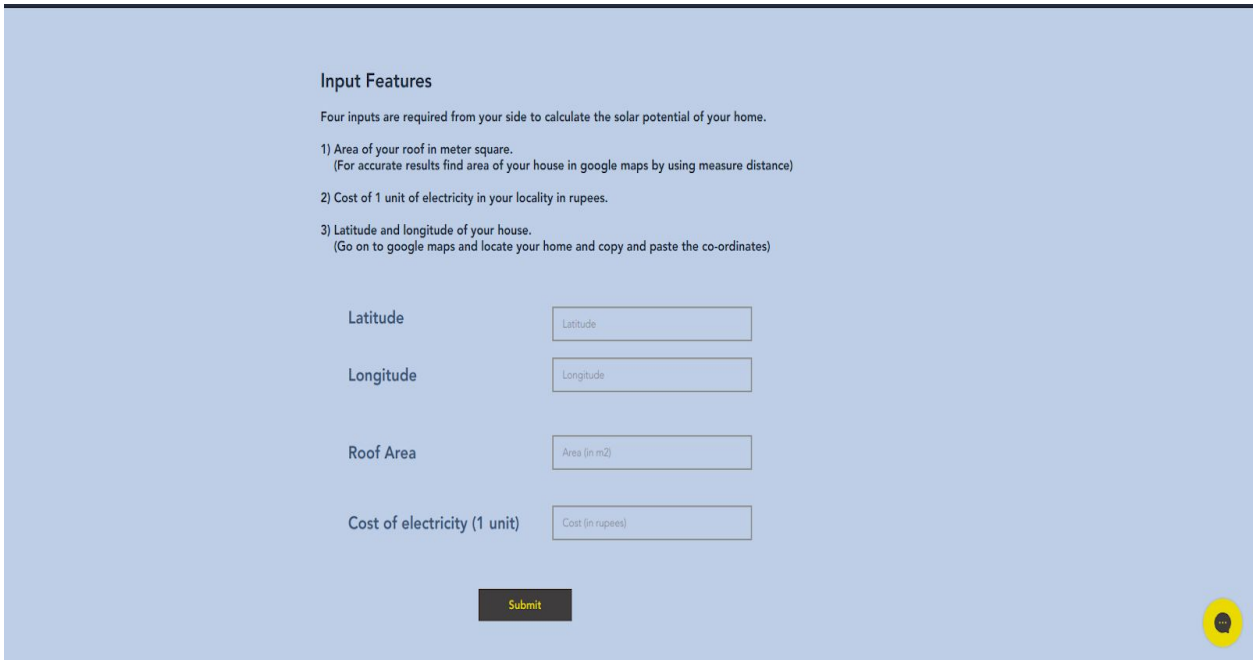
- The common people can now know the installation cost for their roof and the annual return from that investment in just one click.
- The most important part is that they can know the year in which their investment can be returned and hence they can now easily plan their installation and if they require loans then they can plan their downpayment.
- This is a great step towards sustainable energy and will encourage common people to choose solar energy over conventional sources and hence they can contribute towards their environmental responsibilities.

Future Works

- The technologies like 3D-modelling and LIdar must be incorporated to get the better predictions.
- Weather conditions must also be included to get more accurate results.
- We have to incorporate energy lost by the roof due to shadows of trees or other objects between roof and sun.

Glimpse of our website

URL: https://dnd6524.wixsite.com/solar-sunroof



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