International Journal of Engineering & Technology, 7 (3.34) (2018) 4-7

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

City - Scale Spatial Data Infrastructure for Solar Photovoltaic Energy Generation Assessment

[1] R. Gowri Shankar Rao, [2]N. K. Rayaguru, [3]N.G.Renganathan,[4]Sunil Kumar Thakur

[1]Department of Physics, Vel Tech Rangarajan Dr Sagunthala R & D Institute of Science & Technology,Avadi, Chennai.
[2,4]Department of Electrical & Electronics Engineering, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science & Technology, Avadi, Chennai.
[3]Department of Chemistry, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science & Technology, Avadi, Chennai.
**Corresponding author E-mail:* gshankarrao@veltech.edu. in,rayagurunk@veltech.edu.in

Abstract

Spatial data plays an vital role in decision-making for development of smart cities. As it is very evident that the development of smart and sustainable city mainly depends on its physical infrastructure such as intelligent transportation, smart energy, smart metering etc., This paper provides an analysis which aims using the spatial data infrastructure tools for estimation of the region based solar PV potential generation for a specific urban region . This analysis would afford a great insight in deciding a city scaled potential energy production and planning, an estimate of the geographical PV potentials for solar power generation is adopted. The total PV potential is evaluated for a specific defined area and compared with the local electricity demand. The outcomes comprise of an initial valuation of the town's solar potential that can be used to upkeep organization decisions regarding reserves in solar systems. Successful implementation of SDI finally depends on the political governance and their framing policies.

Keywords: *Solar PV, GIS software, Infrastructure, Urban planning, S./’patial data infrastructure(SDI)*

1. Introduction

GIS is an emerging technology for surveying and planning to a rapidly expanding technology. It helps in understanding our planet in a better way . It bridges the gap between various sectors. It is quite interesting to know that there is very little knowledge prevailing on geo spatial analysis. Geospatial data refers to the geographic information plotted on map which contains boundaries and topologies, also proving information on roads connecting cities , state borders and data is mapped on that. Geospatial data can also be defined as mapping of a physical object in terms of geographic coordinate system. The identification of shape, size and location of an physical parameter could be done using the spatial data such as mountains, lakes etc., the estimation of solar energy requires the use of high resolution geospatial software’s. GIS based software provides us to manipulate, analyze and manage in addition to model to evaluate the solar resource. The modeling not only stops only at evaluating but also it has to provide solution for transferring the data to the communities and also to make an decision whether it could support the local energy demands. Katrina Adam et.al., has developed a technique for quick assessment of feasibility of utilizing the solar resource for different cities through extrapolation procedures [1]. Thomas Huld, has used the open source software PVMAPS tool for estimating solar radiation and PV power on liable planes over vast topographical areas. The investigation have been carried out for annual energy output systems of 1Kwp [2]. Yan-wei et al., had provided case study for investigational estimation of pv power at the speficic region of interest using high resolution network atlas and carried out extensive financial study on payback period for pv generation [3].

2. Components of Sdi

Virtual The different components of spatial data infrastructure(SDI) includes governance, data sharing, training, cooperation, digital base map, statistical places, hardware , software networks etc.,

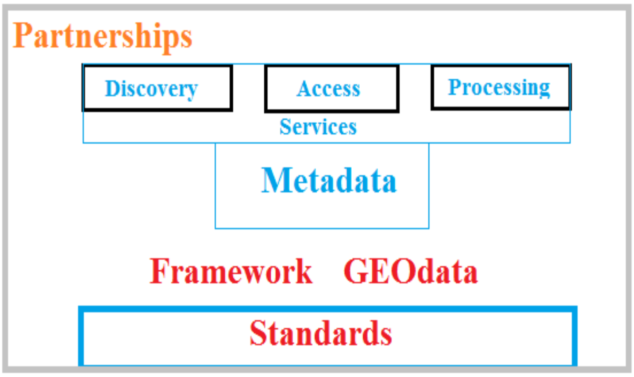

Fig 1: Components of SDI

The first element is the meta data which is adopted in most countries, it can apply to data, services , it provides documentation of resource, permitting search and comparison of geospatial resources .it is used to describe services and data .Meta data is classified in to two groups frame work and Geo data. Frame work layers includes hydrographic data, transportation, elevation, government unit boundaries etc. the services such as discovery services provide by national catalog over many collections. National geo portal supports download of data, links to websites share data collection plans etc.

Sergio Castellanos et. al., has reported on the different methods to evaluate the roof top PV potential and has provided studies on scalability and resolution for later time assisting the administration [4]. ElieserTarigan et. al., presented digital model for various dimension and analyzed the PV installation results using SOLARGIS-PV Planner, particularly for domestic positioning and concluded that for homely PVsystem the design is not viable economically [5]. Zulkiflee Abd Latif has exposed the LIDAR technology incorporated with the Geographical Information system to figure the satisfactory location to position the PV panels [6]. According to magazine release, renewable energy stands as a substitute solution for sinking the request on air pollution from traditional energy systems [7]. Steven Jige Quan et. al has developed a scheme based on energy balancing model which can be extened from single bulding to urban sytem using the scaled data and also provides reasonable trade off between speed and accuracy [8]. Sabo Mahmoud Lurwan et. al., has highlighted on identification of ideal sites to fix significant smart grid-connected Photovoltaic (PV) power plants. Normally the datasets given as input, comprise digital elevation model, road networks, grid lines and average solar radiation on a daily basis and predicted that the annual carbon emission reduction offset from the estimate 2020 CO_2 emission is set at 13.2% [9]. Angelamaria et. al., has investigated on a earthly information databank System based up on the availability of land use, residential energy consumptions and has experimented a GIS model in a widespread space of central Italy in europe. [10].

In this paper the primary objective is to evaluate the solar pv potential a specific region of Chennai city initially, and then the same can be extended for entire city with the utilization of GIS software for studying the parameters such as land availability, temperature of the specific location and radiation etc. Roof surfaces in selected parts of the study area are evaluated and reported on the incoming solar irradiation that could be captured.

3. Solar Potential Yet to Shine

In places like Chennai city a 1kW solar power planned with net metering would cost around Rs.80,000 /- and it would save monthly bill of around Rs.1000 . One of the IEEFA's study of Tamilnadu which sees the state solar energy generation capacity of total 13.8GW and it also accounted that one-fifth of total renewable energy generation in 2016-2017.Tamil Nadu solar policy 2012 includes a rooftop capacity target of 350 MW. In three phases of 100, 125 and 125 MW (per year), a total of 350 MW is to be developed during 2012-2015. The positiveness of solar power is that the cost is dropping down at a rate of 4.4 percent worldwide each year.

4. Methodology

There are some recognized open source GIS softwares such as SOLARGIS, GRASS GIS, Quantum GIS, MapServer, and many others. The primary data is available globally as they provide solar parameters such as Global Horizontal Irradiance (GHI), Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DIF) and Global Tilted Irradiance (GTI) and Meteorological parameters including Air Temperature ,Wind speed ,Wind direction ,Relative Humidity etc., The data is systematically updated with different domains such as satellite record to the recent month even up to present time, it also provides customized data up on request from primary hourly time series.

SOLARGIS structure employs a statistically accumulated parameters in the list with which is updated through a constant time interval . Basic feedback factors enable to reflect key features of the scheme, such as its location, geometry, type and setting up of modules, inverters efficiency and losses occurred in AC and DC segments. The model computes reflectance losses at the exterior of PV modules and additional losses because of temperature, operating performance of modules and irradiance in a site-specific climate conditions. The other system losses, mainly at the AC and DC sections are to be set by a user[11], [12].

SOLARGIS PV software are widely used in several PV applications in addition to forecasting , some of the features include

- Prefeasibility analysis through online
- PV power plants performance assessment
- Forecasting of PV power forecasting
- Analysis of PV intermittency regionally

The data are accessible via online using SOLARGIS application using intereactive services which includes iMaps, pvPlanner and pvSpot applications.

5. RESULT

5.1. The Case Study of Chennai and Solar Radiation Data

Chennai region is confined by Latitudes of 13° 08' 50" and Longitudes of 80° 18' 20" respectively. The city receives its monsoon rainfall during the months of October till December.

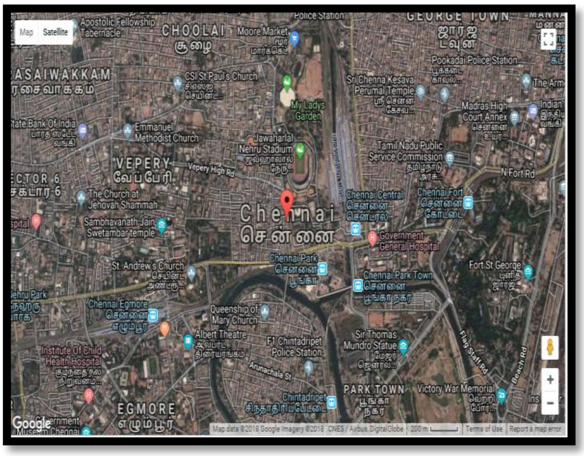

Fig.2: Land imagery of Chennai

This study is carried out using SOLARGIS tool for the regions specified. Here an attempt is made to estimate the potential of incorporating renewable forms of energy for distributed electricity production.

5.2. Photovoltaic Geographic Information System

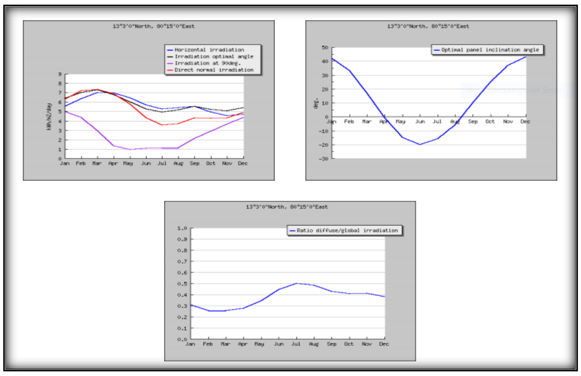

Fig.3: Solar irradiation data

Tilt angle plays a vital part in the solar energy optimization and it is also evident that it is key to obtain optimum energy yield. The optimal tilt angle for Chennai is estimated for different seasonal changes using the software [13].

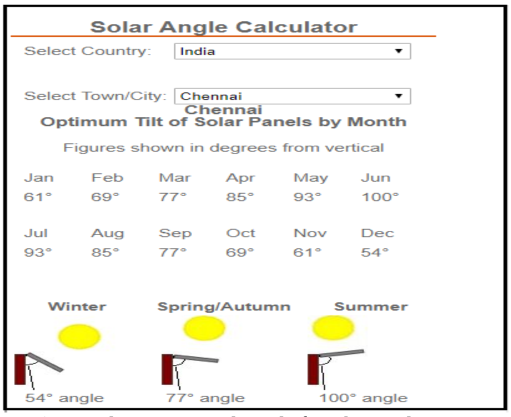

Fig.4: Solar optimum tilt angle for Chennai location

5.3. PVGIS Estimates of Solar Electricity Generation

Simulation using SOLARGIS PV palnner has been executed to obtain the optimal specific energy production . Fig 4.shows the optimum panel orientation from the horizontal on a monthly basis.. Simulation results shows that variation of panel would affect the energy production.

Location details : T Nagar Latitude: 13◦ 2' 25" North Latitude 80◦ 14' 1" East, Elevation 13m.a.s.l.,Solar radiation data base used: PVGIS-CMSAF Minimal power of the PV system: 1.0 KW Predictable losses due to temperature and low irradiance :14.0 % (loss due to angular reflectance effects:2.8% Other losses like (cable, inverter etc.,) : 14.0% Joint PV system lossess:28.2 %. Inclined axis trailing system optimal inclination: 14◦ .

Table1. shown below gives the typical daily electricity production and periodic average electricity production of the given scheme. The table1. shows the monthly irradiation data taken for the specified location T.Nagar, Chennai, Tamilnadu, India from photovoltaic GIS maps online software[14].

Table 1:

	Average daily electricity production (KWh) Ed	Average Monthly electricity production (KWh) Em	Average sum of daily global radiation per square meter received by modules of the given system KWh/m2 Hd	Average sum of global radiation per square meter received by modules of the given system KWh/m2 Hm
Month				
Jan	5.92	183	8.18	254
Feb	6.71	188	9.34	261
Mar	7.03	218	9.87	306
Apr	6.56	197	9.23	277
May	5.79	179	8.15	253
Jun	4.87	146	6.85	205
Jul	4.45	138	6.24	194
Aug	4.65	144	6.54	203
Sep	5.06	152	7.12	214
Oct	4.66	144	6.55	203
Nov	4.52	136	6.31	189
Dec	4.85	150	6.69	207
Year	5.41	165	7.46	227
Total for year		1980		2720

From the table using an crystalline poly silicon panel it could be expected daily specific with an inclination angle of 14 degrees could yield an daily specific electricity production of around 4.65 – 7.03 KWh /m2 / day or an yearly production is calculated to be 1980 KWh/m2 .Fig 5 depicts the monthly energy production of a stable angle PV system.

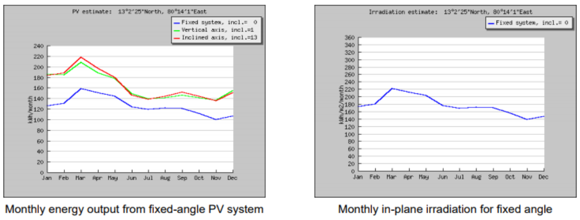

Fig.5: Monthly energy output pattern for stable angle PV and irradiation

6. Conclusion

An investigation has been carried out with the simulation model by means of SOLARGIS PV Planner to evaluate size and solar PV potential performance in Chennai ,T.Nagar .The average totality of comprehensive irradiation on daily basis on plane surface in T Nagar is found to be 5.87 kWh/m^2 with primacy of diffuse radiation. More over ,it is concluded that a typical family with a load ratings of 1 kVA in Chennai could commonly use the basic appliances such as light loads etc,. The results of the simulation determined based on the basic load and it is clearly evident that energy is quite sufficient for basic house hold electrical appliance with the poly crystalline solar panel.

The paper benefits under and post graduate students to use GIS software in the field of renewable energy. They can have an exposure to geospatial modeling of assessment over a small region. A study of environmental impact can be established , strategic planning based upon forecasting can be made and economic policies can be framed in concern with local electricity board. Online data monitoring feasibility is available and this could justify the investment made in future planning of solar pv parks. By integrating the data the cost analysis for be predicted for the past and future. These finding will improve to understand the regional pv potential capacities.

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