Design of an Intelligent EV CS with PV Generation Plant a Brief Analysis of Optimal Location Estimation

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ABSTRACT:
For addressing the pressing needs for the development in advanced clean and renewable energy technologies in order to address some of the challenges of climate, pollution and effective energy utilization that are faced by the nation. Electric vehicles prove to be a best solution to address pollution due to its lower emission, maintenance requirement. Among many the best option that in abundance is available in India is Solar photovoltaics. The aim of our paper is to obtain the best locations available for setting EV charge stations. Based on the available model of Battery electric vehicle (BEV) and the range of the vehicles this form of location determination is fully. The charging stations location determination and distribution is an example of optimization problem. For this report we are most focused on the estimation of optimum locations for setting up of charging stations in Kolkata and for renewable energy generation the factors that determine the performance of solar panels are temperature, radiation, inverter efficiency, climatic condition and other conditions are taken into consideration.

1. INTRODUCTION:

Energy generation through renewable means and electrification of automobiles are emerging as one of the prominent strategies to fulfil the energy scarcity and environmental concerns, and this trend follows an expected growth profile [1]. Recently, many automobile companies have taken the concept of the vehicles to the next level by designing vehicle with electric drivetrain and smart controls. This initiative is welcomed as it has a greater efficiency since the electricity, they use is produced in abundant quantities in the power plants as compared to the fuel-based cars which utilize only 20% of the fuel during combustion process. PV energy generation at the roof of commercial and public buildings are considered as an efficient way to meet the energy demand as an environmentally friendly mode of generation, although which needs some prior investment and maintenance throughout its operational lifetime [2]. The green and clean energy generation methods like solar and tidal, where solar being naturally abundant in most parts of India, are important component that could be used to provide ancillary energy. To reduce the carbon footprint, many researchers have integrated PHEV and BEV charging stations with PV generation [3-6]. As the nature of these sources are random, so to obtain a stable output spinning reserve or additional storage (like PSH) are often utilized [7-9]. A novel optimization algorithm is proposed to target the reduction in total operating cost for a charging station integrated with PV, Pumped-storage hydroelectricity (PSH) facility and a control building. Beforehand the predictive data are obtained and then used to model control-based method which is then utilized by the Real time site controller for those predicted data analyses. Load is classified by the significance and flexibility. Kolkata has been chosen for the purpose of our survey because it has a situation where DC power is available for use, it is easier to set up DCFC (DC Fast Charging) for public transportation vehicles with variable tariff for different customers. DCFC EVSE units are more suitable options for continuous and daily operations as it can support charging the electric buses and cabs more efficiently.

2. STUDY GOALS AND OBJECTIVES:

The goal of our paper is to:

- Identify the ongoing practices and standardization for power and communication infrastructure to accelerate the manufacturing and deployment of electric buses, cabs and to identify the true potential of EV on reducing the carbon footprint from our environment.
- Analyze existing public transport system and electricity distribution infrastructure to enable a fast transition at most economical terms and the efficient way.
- Design and develop a PV generation station which would purely supply the base loads during needs.

3. LITERATURE SURVEY:

Assessment for setting up practical charging stations: For adoption of EVs and deployment of charging infrastructure depending on a sustainable and effective model is necessary. At present, low uptake of EVs results in lower utilization of the assets and the utilization of the viable EVSE units, for which discharge based incentive is also facilitated. Further, due to rapid technological transitions in battery and anticipation on standards of EVSE, the technology risk seems to be higher. Due to this, investors are skeptical of deploying such an infrastructure. This study is only prevalent for the existing models in the current Indian market. It has been further undertaken into observation that the vehicle would deliver 130 kilometers on single charge. The charging station has a single DC charging point and could be used for charging vehicles with an average battery capacity of 18.55 kWh [10].

Utilization of existing resources: The charging station network in West Bengal which could be made scalable and flexible by utilizing the available tram lines, proposes an effective method for commercial /passenger vehicle fleets to develop an economical proposition over a short period of time. Converting cabs and buses from ICE to an electric version in a planned way would possibly be a best solution for this transition [11]. This would reduce about 66% of the pollution generated by these internal combustion engine (ICE) counterparts, which for the most part in their daily routine is idling in the traffic. Also, the distance that is travelled in a given day by these vehicles should be that large which makes the conversion of public tax fleet to EVs much more attractive.

Practices for adoption: For adoption of EVs most developed countries have set some targets which they have to meet on a yearly basis. While countries like India that are in a phase of development are in search for favorable environment, policies and incentives.

Country	Sales in 2016
United States	84,850
Canada	4,160
European Union	155273
India	~1,000
China	2,66,000

Table:1

EV charger standards in India: A committee appointed by the Govt. of India (GoI) prepares the specifications for EVSE. This covers the various standards for both ACFC and DCFC chargers, which was only prepared for the Indian market. These specifications include following type of chargers:

- AC Chargers
- AC Public off-board Chargers up to a maximum charging rate of 3 kW.
- DC Public off-board Chargers

4. CHARGING AND GRID CONNECTIVITY GUIDELINES:

All charging infrastructure Direct Current Fast Charger (DCFC), Alternating Current Fast Charger (ACFC) classified under electrical code purview. If the charging infrastructure is a HT connection (11 kV or higher) the substation design details is submitted to the regional Distribution Company of India (DISCOM) for review (location public safety, electrical protection/relaying, etc.) and approval. Substations that are located in proximity of public spaces require other municipal clearances like water, noise, fence clearance surroundings, fire, etc. These approvals are required for each location of a charger to be installed by a third party (other than DISCOM). The extent of such charging infrastructure drawn from an existing source-point, then such process is much simpler. Addition of captive Distribution Transformers (415V application) for operation will go through the DISCOM approval process. Typically, capacity requirements under 600kVA could be delivered either through an existing DT or through the provision of a captive DT. All load capacity requirements above 600kVAand up to1500kVA will require an11kV connection with the applicant providing necessary voltage step down transformers and a functioning substation that interfaces with the charging equipment. The impulse characteristics of fast chargers (typically 3C and above) are to be studied for power quality impact and if significant, the independent charger may be connected to 33kV (instead of 11 kV) or require customer-owned mitigation equipment to reduce impact from impulse.

5. OPTIMAL LOCATION ESTIMATION:

After examining the studies that are elaborately discussed in [12], the EVSE or charger location problem has been examined by using parking information. Determination of optimum locations depending on the average number of EVs on the road and the average range is taken under consideration. Kolkata road map is plotted on a custom-made map by using Mapbox Software obtained from the satellite via spectral clustering. For removal of some of the standard clustering errors that have creeped into the data set image processing algorithms like erosion, dilation and thresholding [21] are used. Also, using the total number of datermined charging stations optimal charging locations of EVs in West Bengal are estimated by various clustering approaches such as spectral clustering and GMM (Gaussian Mixture Model). The road map of Kolkata with Private bus routes is shown in Figure 1. The image is fed to Mapbox software which is a mapping platform for custom designed maps and it is preferred due to its convenience and being a flexible software. The red lines shown below indicate the roads covered by any private bus service provider. With the help of spectral clustering the minor errors on the road layers are eliminated by morphological image processing algorithms Fig3(a) & Fig 3(b). The yellow dots denote the optimal locations.

Spectral Clustering: We have to assign unlabeled data, identical data points are assigned to the same group of data. This technique defines the approach of using the roots to find the nodes in a graph based on the connected edges. Here the clustering is applied to a normalized Laplacian Matrix in the graph[13]. Spectral clustering could be classified into three clustering objective functions which are the Ratio Cut, Minmax Cut, and the Normalized Cut. Clustering objective functions are shown as

$$□ = \sum_{1 \le □ < □ \le □} □\frac{(□, □_□)}{□(□_□)} + □\frac{(□, □_□)}{□(□_□)} = \sum_{□=1}^{□} □\frac{(□, □_□)}{□(□_□)}$$

where $□(□_□) = |□_□|$ □□□□□ □□□

$\sum_{□ \neq □_□} d_□$ □□□□□□□□□d □□□

$□(□_□, □_□)$ □□□□□□ □□□

and $\bar{□}_□$ is the supplement of subset $□_□$ in the graph G [13].

A set of points $□ = \{□1, \ldots, □□\}$ in $□^□$ desired to cluster into k subsets as [14,15,16]

Gaussian Mixture Modelling: GMM is a probability-based model showing the presence of sub-clusters in all observation. Mixture models are utilized to determine features of sub clusters [17,18]. Some methods like unsupervised learning or clustering process are used in determining mixture models. However, these are not valid for all feature extraction process. Mixture models are assumed as combinational models. In mixture model, the members in the cluster are described by a combinational model where the total size of the cluster is set to 1.In [19] derivation and discussion of the probability density function is done using this technique. GMM is used in this paper due to some advantages which are not complex and robust to different levels of noise [20]. In the image, it is considered to have a finite number of gray-level density function to be present for GMM to be applied. Modelling of each observation point on the image is done by one Gaussian distribution and each distribution of observation points can be given as GMM. Choice of likelihood function $(□ | □)$ on the features is significant to understand the likelihood ratio. GMM as the best likelihood function is described in [20]. The mixture density can be given as :

$$□(□|□) = \sum_{□=1}^{□} □_□(□)□_□$$

A set of M weighted Gaussian densities $□_{□(□,□)}$, where each is represented by a mean D×1 vector, $□_□$ and a D×D covariance matrix, $□_□$ are as follows

$$□_{□(□)} = \frac{1}{2^{□/2} |□_□|^{1/2}} \exp\{-1/2(□ - □_□)' (□_□)^{-1}\}$$

where $□_□$ are the mixture weights, it satisfies $\sum_{□=1}^{□} □_□ = 1$. The density model parameters are $□ = \{□_□, □_□, \Sigma_□\}$ and i= 1, 2,…M also x is a D dimensional featured vector.

Thresholding: It is a simple way of segmentation of an image where the object is separated from its surrounding bodies.

After thresholding an image (□, □) is defined as

$$(□, □) = \begin{cases} 1, & □(□, □) > □ \\ 0, & □(□, □) < □ \end{cases}$$

Where 1 is object and 0 is background.

Erosion and dilation: Dilation is the process of addition of pixels to the surface of objects and defined structures in an image, while erosion is the process of removal of pixels from the surface or edges of objects.

Energy ($□_□$) of the on-road vehicles are given as follows

$$□_□ = \sum_{□=1}^{□} □_□$$

where $□_□$ is total energy of specific layer and n is the total number of the road layers. The parameter of energy is related with road width; therefore, clustering operations can be performed in proportion to the density of the roads. The number of EV charge station is determined by the ratio between specific road layer energy and total energy of the roads [22].

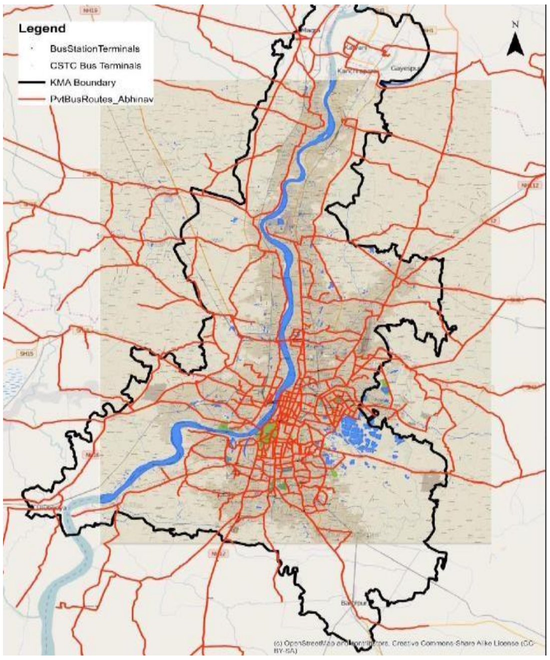


Fig1:Private Bus Routes

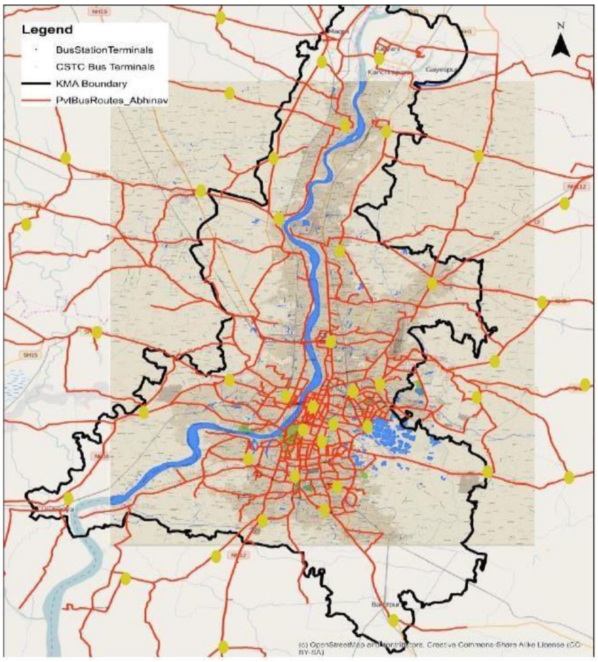


Fig2: Private Bus routes with optimal locations

Fig3: The zoom in results for the road

Fig4(a)

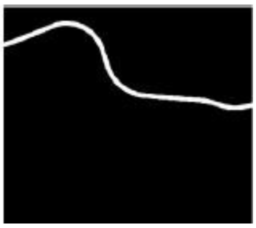


Fig4(b)

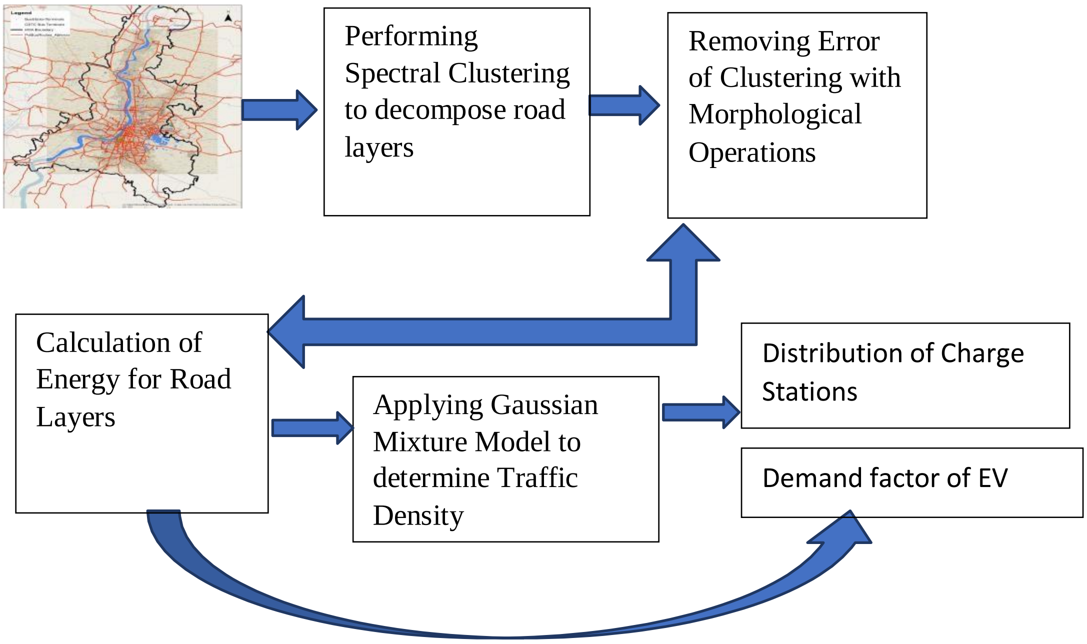


Fig: 5

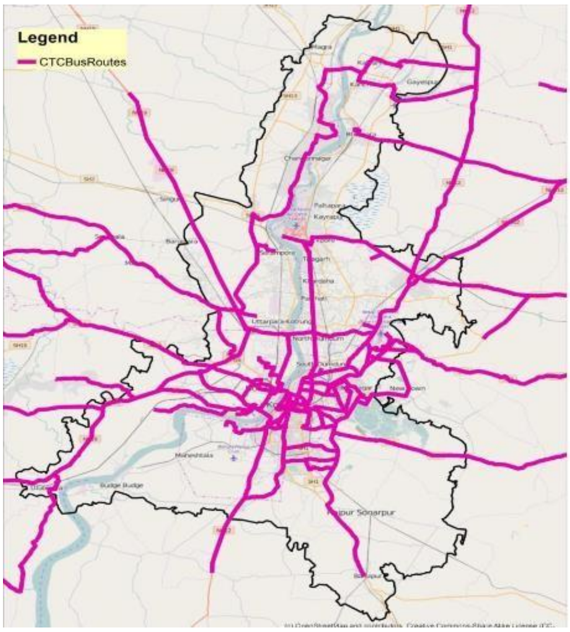


Fig 6: CTC Bus Routes

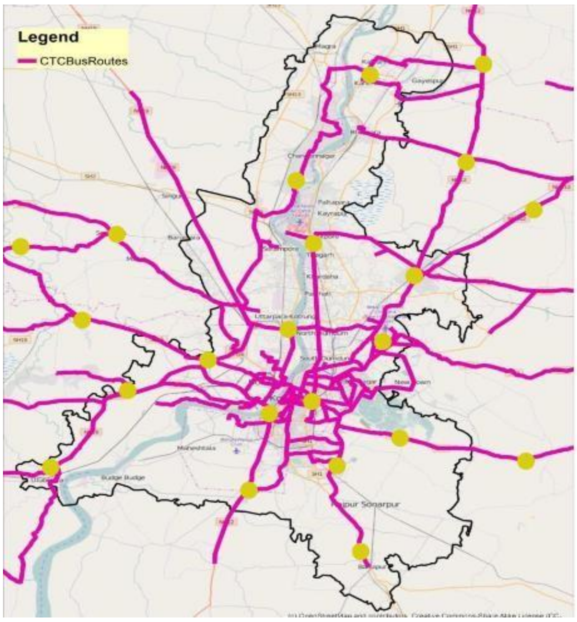


Fig7:. CTC Bus routes with Optimal locations indicated using Mapbox Software

The estimated EVSE locations for CTC bus routes are also indicated with yellow dots.

6. PROBLEM IDENTIFICATION

The concerned idea of the work is to develop an algorithm to optimally charge electric vehicles using available solar energy to overcome the following shortcomings:

- Immense load on grid
- Grid Infrastructure upgradation Cost
- Unordered charging of hurrying EV owners [23].

Solar power plant design:

To meet the production goals and for long-term commercialization of service based solar gen plant which requires affordable, efficient and reliable systems that meets the demand of utility consumers and cost reductions are available through different materials of varied specification, design and fabrication techniques developed by the power industry for the need to lower down the cost of traditional generating stations can affect significantly to the cost savings. Higher generation through proper design and use of efficient system components effectively by means of lowering the cost of power. Some critical factors which must be kept in mind during design include proper selection of modules, optimum angle of tilt, minimization of ohmic losses with proper selection of conductors, selection of efficient transformers and inverters etc. Use of reliable and long-life components is equally essential for expensive renewable energy plants. Capacity Utilization Factor (CUF) defines the viability of the solar plant. It states that actual energy output divided by maximum possible output that could be produced if all the parameters like solar insolation, azimuth, angle of tilt were optimum during a period of one year. The energy that is generated from our designed power plant is fed to some software. HOMER, RETScreen and WRDC is used for that purpose.

CITY	Horizontal Radiation	Optimum tilt Radiation
New Delhi	19.67	21.54
Kolkata	17.47	19.07
Pune	20.4	21.94
Chennai	20.12	20.99

Table2: Azimuth and tilt values of various states [source: WRDC].

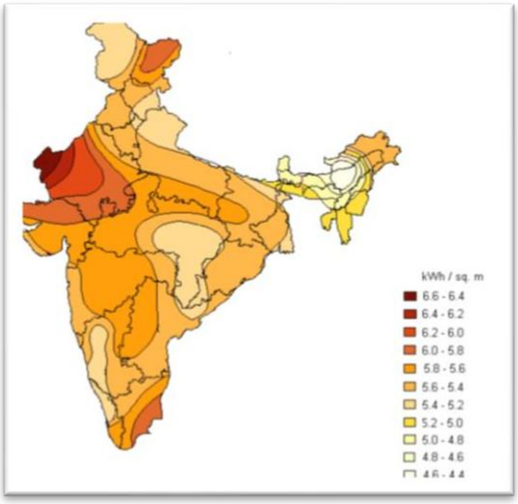
The design parameters are later estimated from these software which are solved later.The WRDC is a data center that is sponsored by WMO. Generally, it provides solar irradiation data and radiation balance sheet.

Software Discussion:

HOMER: HOMER is paid software application. It is used in clean energy generation plant management and for designing renewable energy plant design.

RETScreen : The RETScreen is a software package that is specially designed for management of renewable energy resources like a generation stations which could be done with standard management software's like LabView. The software is used for identification, optimization, assessment of renewable energy projects.

Mapbox : Mapbox is a provider of custom made online maps for websites, educational purposes, defense and various application.



. Fig8: Solar radiation zones as per IMD database

By using efficient methods of design various losses in PV Solar systems could be avoided such as soiling, reflection losses, MPPT, and inverter efficiency. A detailed study was carried out to analyze the change in characteristics for a change in solar irradiation (Tilt of Surface).

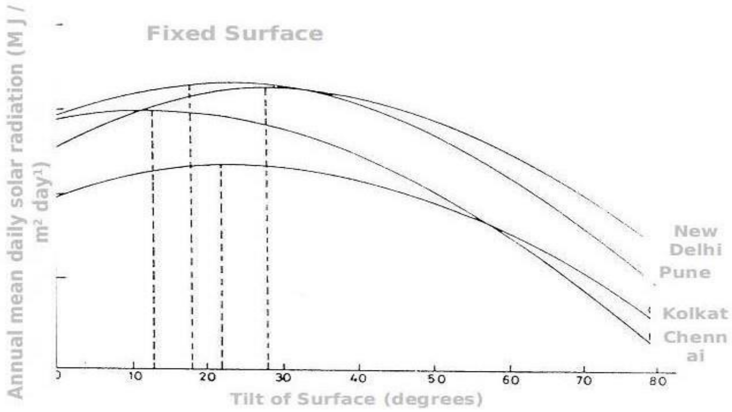


Fig9: Radiation at different tilt angle

Assumptions for HOMER software

For Polycrystalline Silicon Modules

Type		c-Si
Capacity	kW	1,500.00
Manufacturer		Moser Baer
Model		MBPV-CAAP
Efficiency	%	15.0
Nominal operating temperature	Degree C	47
Solar collector area	Sq. meter	7,792.00

Control method		MPPT
Miscellaneous losses	%	7.5

Table:3

For Amorphous Si Modules

Type		a-Si
Capacity	kW	1,500.00
Manufacturer		Moser Baer
Model		MFBT(Power series)
Efficiency	%	7.0
Nominal operating temperature	Degree C	47
Solar collector area	Sq. meter	16,667.00
Control method		MPPT
Miscellaneous losses	%	7.5

Table:4

CUF at various locations in West Bengal

Sl No.	City	Average Radiation	Ambient Temp.	Crystalline Output	CUF	Amorphous output	CUF	Optimum Tilt.
1.	Kolkata	4.50	26.9	1378.60	15.74	1458.30	16.65	22.5
2.	Darjeeling	4.80	9.0	1641.00	18.73	1663.60	18.99	27.1
3.	Siliguri	4.85	19.4	1626.00	18.56	1728.30	19.73	26.5
4.	Purulia	4.70	24.3	1484.00	16.94	1562.46	17.84	23.4
5.	Malda	4.60	25.8	1573.00	16.61	1752.66	18.69	25.6

Table:5

7. PROPOSED SOLUTION:

In order to formulate the problem discussed above, various hypothesis was made and certain parameters need to be considered. The parameters which need to be considered are the vehicles' battery's initial state of charge, vehicle's rest time and different vehicle arrival timings at a workplace. Also, the solar pattern in the locality is to be known [24].

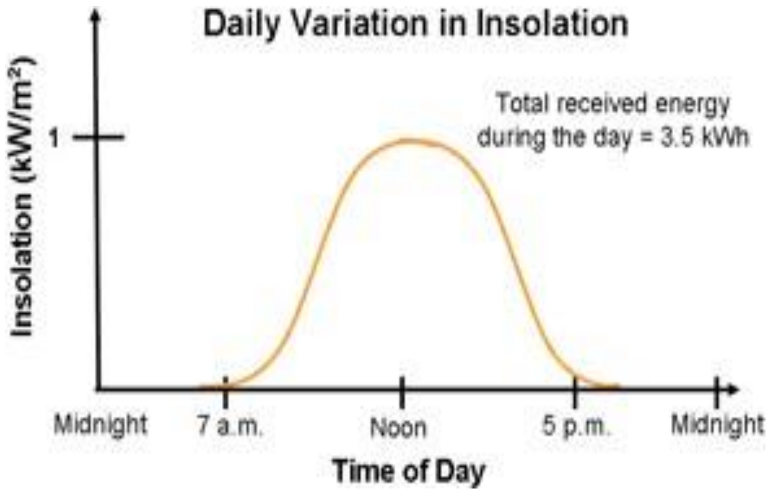


Fig 10: The approximate daily variation in the insolation pattern

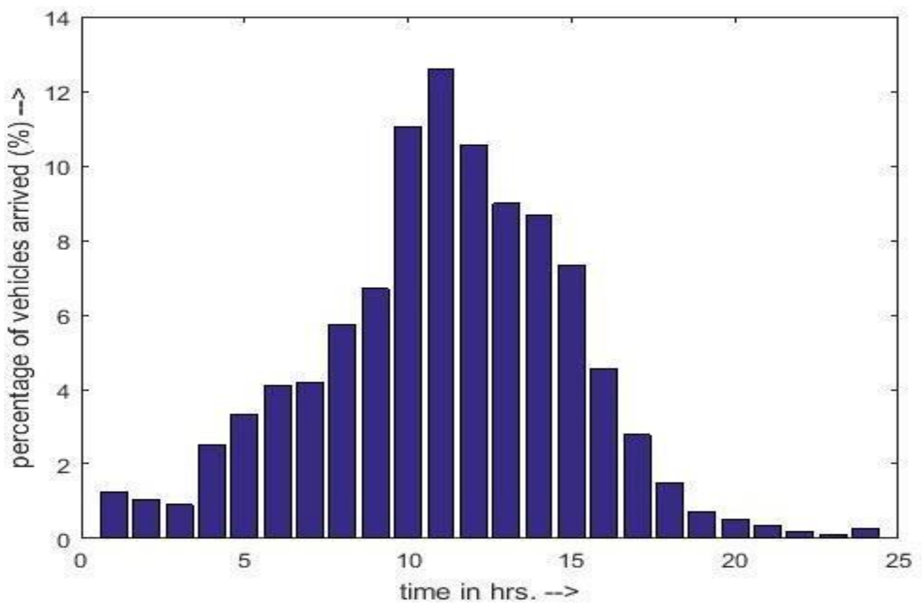


Fig 11: The vehicle arrival pattern at the workplace

8. CHARGING SYSTEM DESIGN:

For the charging operating system we have considered a 10kW bidirectional inverter, and a 5kW array of 6.6kW level 1 and level 2 units. The bidirectional inverter controls the power flow between different units. The output is two ports (DC) which is fed to the grid and also EVSE units a different location. A real-time control system should be, which could be designed by SCADA and should consist of an on-site transducer and supervisory computer will be able to communicate with the different units like the charger array and bidirectional inverter using Modbus to monitor and control. The on-site controller monitors the PV power, the motor status, the EV charging load, the status of the grid. To estimate the periphery of solar irradiation the weather data is extracted from a standard weather website.

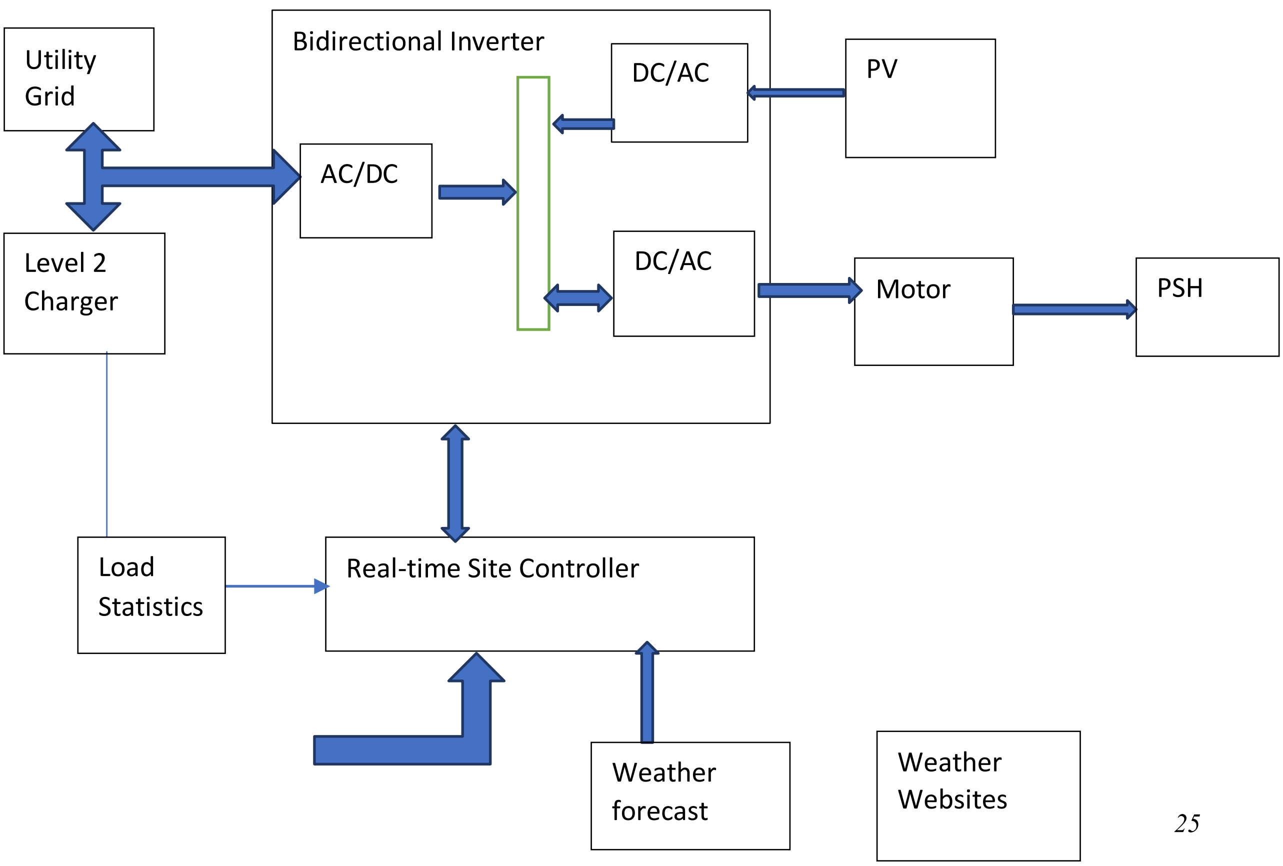


Fig12: Charging system block diagram

This block diagram denotes the working principle of the model that we proposed. This model can be used as a reference and could be implemented in any location.

9. CONCLUSION:

We have proposed an innovative approach in this paper to determine the best fit locations for setting up EVSE at specified regions. Among the various options that have been considered to enlarge the current renewable energy penetration to the grid, one achievable approach is to utilize electric vehicles (EVs) as energy storage to manage the variety in sustainable power energy generation, given that the situation of EV proliferation moves toward becoming a reality [25]. By 2020, PEVs will supplant up to 35% of the gas vehicles in the US automotive industry. Also, an application of smart and sustainable micro grids is justified by connecting the EVs to it. Further to implementation plan and recommendations, to accelerate EV adoption (public or private), the Indian policy makers, regulators and other authoritative bodies should evaluate global practices, while examining the local issues such as cost, impact on electricity network, and customer charging behavior. India must develop specific EV needs based on data analysis of the Indian market conditions and work with global and local OEMs and experts to fulfil the government goals on electric mobility and local manufacturing. The city of Kolkata represents a latent opportunity for electric mobility with new economic opportunities, while addressing the energy production security objectives and driving the city's future toward its planned low-carbon presence. The improved environmental air quality and health benefits and also reduced particulate matter concentration will provide its citizens a new pathway towards a healthy life.

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