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Solar based electric vehicle charging station

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Abstract- **This paper investigates the possibility of charging the battery of electric vehicles at a various working place like offices, colleges, hospitals, universities etc in Delhi, India using solar energy. We have collected information from the Indian Meteorological Department and it is used to determine the optimal orientation of solar panels for maximum energy production in Delhi. The seasonal variation in solar insolation is analyzed to determine the energy available for EV charging. Due to low range per charge people prefer to rely on conventional vehicle, so by increasing the number of charging station in between every 25 km. India's per capita energy consumption is 23.35(GJ) gigajoules. India ranks 3rd in oil consumption with 211.5 million tons in 2016, after China and USA.**

Keywords— Battery, Solar panels, Electric vehicle, Charging station, Smart charge.

1. Introduction

India is gone under rapid economic change past three decades including Globalization, Privatization like reforms. India is fourth largest automobile markets in the world today and having highly increasing middle class population with buying potential, simultaneously the petrol price has also increased more than 45% in 12 different steps in last two years [2]. There's need of alternative technology in automobiles such as electric vehicles (EV). India is also ranking 4th in carbon emission in 2018, it means we are at the verge to kill the future of human life [1]. The total CO2 emission has been increased to 988.6 tonnes in year 2018. Solar energy is renewable form that will never exhaust, with coming years we will be totally reliable on solar power. India cost cheapest per MW to produce electricity from solar in the world. The highest solar capacity of India is 1300MW in Telangna.

1.1 Comparison between three different fuel types keeping total expenditure Constant

We know that day by day population is increasing and India is 2nd most populated country in the world. Number of vehicles for transportation is also increasing, according to Ministry of Statistics and Program Implementation total of two hundred thirty million are registered. Lets us consider a case where we compare the fuel efficiency and cost effectiveness of these three types of vehicle, Petrol engine vehicle, Diesel engine vehicle and Electric vehicle. Per Liter cost of petrol, diesel and electricity is taken as Rs. 72/ltr, Rs. 65/ltr and Rs. 6.5/kwh. We have taken Tata Tigor specification, (142 km/16.2 kWh) with total discharge up to 20%. The milege for diesel engine vehicle is 28kmpl and petrol engine vehicle is taken as 20 kmpl. We have taken an average family expense on fuel is Rs 10,000 for whole year, according to this following table is calculated.

Fuel	Petrol	Diesel	EV
Cost(Rs)/unit or L	72	65	6.5
Consumption	139 Ltr.	154 Ltr.	1538 kWh
Range/year	2780km	4312km	9240km

Table.1 comparison of distance covers in different fuels

1.2 Comparison of CO2 emission between conventional vehicle and an EV for the same distance travelled.

A single liter of petrol produces 2347g of CO2 while 1 liter of diesel produced 2667g of CO2. Here we have taken a case that a car travels 10,000 km in a year. By using the above data like mileage we calculated the number liters of gasoline burned and also the amount of Kwh energy required by EV to recharge [9]. For production of 1kwh electricity the carbon emission of a nation is about 660.6g. An average EV requires 30kwh of electricity to travel 100 miles (Nissan Leaf) [6].

fuel type	Petrol	Diesel	Electricity
Energy req.	500 Ltr	357 Ltr	793kwh
Co2 emission	2347g/ L	2667g/L	660.6g/kwh
Annual rate(CO2)	1173.5 kg	952 kg	52.38 kg

Table. 2 comparison of CO2 emission of different fuel

2. EV charging using solar energy

Charging station will play an important role in increasing demand of EV in market, lesser number of charging infrastructure is the main reason for not buying an Electric Vehicle. The optimal charging strategy can help in reducing the dependency of charging station on grid, like we can deploy charging infrastructure in home, offices, hospitals, parking using solar energy.

The installment of charging infrastructure should not fully depend on government body, some private organization should be tendered for maintenance also. In this paper, a 10 KW EV-PV charger is going to be considering that gives charging of EV for up to 10 KW. The cost of a 10KW panel is about 100,000 INR

Fig. 1 Solar based EV charging station

Power developed from solar is variable in nature as the intensity of solar radiation is not constant. So we are going to use a battery of 75KW, which will act as a storage tank for solar produced energy [3].

The battery will charge itself and deliver power to recharge EV's battery; the charging condition will work till it is 90 percent charge then after it will stop charging only discharge [7]. There is also a condition for EV that when it will be 80 percent charge then the rate of charging will be slow and the other EV in queue will get start charging at its maximum rate.

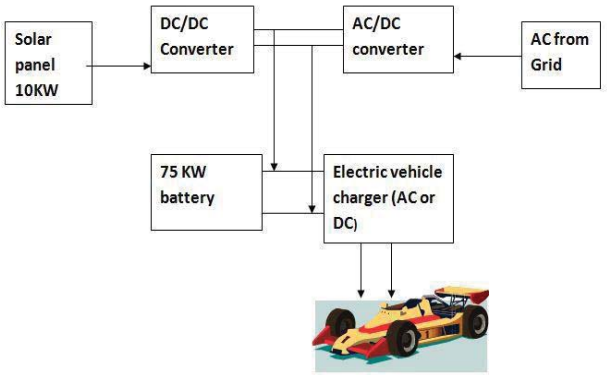

Fig 2 Architecture of EV-solar charger

The above architecture shows how the EV-solar charging station is going to work. First the Solar panel is going to generate electricity which is DC in nature. This DC power is linked to the battery and EV charger module both. If there is an EV connected for charging then it will supply power to charge it, but if there is not any EV so all power will be fed for battery charging. The maximum intensity of irradiance depends on azimuth angle and orientation of panel. Finding the azimuth angle and orientation angle calculation is done by Sohail. The benefit to charge an EV from solar energy is for both, an individual and society, emission free transport medium can create a better living environment. Government of has taken several steps in promoting the Electrical Vehicles.

3. Design of Solar EV charging station

3.1 Solar radiation on inclined surface

At ground surface the solar radiation **(Hg)** come in two components. First component comes directly from the Sun (beam solar radiation or **Hb**) without any dispersion and the second originates from scattering of direct solar radiation from the atmospheric obstacles (diffuse solar radiation or **Hd**). Global solar radiation consists of beam and diffuse solar radiation which is given by:

$$Hg = Hb + Hd \quad (1)$$

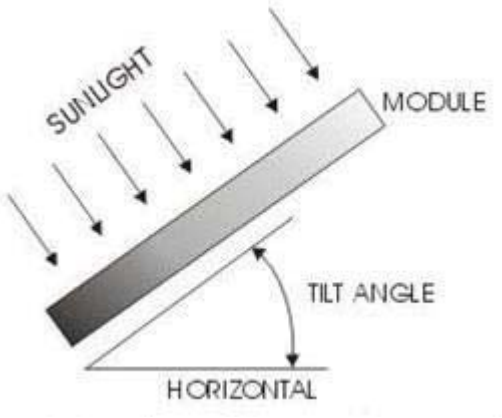

Fig.3 Tilt angle for solar module

The incident solar energy on a panel depends not only upon the incident sunrays, but it also depend on the angle formed between the sun and the panel. The maximum solar energy absorb by the module is when the module and the sunrays is at perpendicular to each other [2]. However, the angle formed between the sun and a fixed horizontal surface will changed continuously throughout the day, so the incident solar energy also varies with the orientation of the sun [4]. Hence the component of incident solar radiation on a tilted surface **(H_T)** at tilt angle **(β)** can be expressed by:

$$HT = Hg - Hd\ Rb + Hg\left(\frac{1-cos\beta}{2}\right) + Hd\left(\frac{1-cos\beta}{2}\right) \quad (2)$$

Here, Rb is the function of transmittance of atmosphere.

3.2 Estimate production at variuos tilt angle

The amount of energy production through a solar panel is direcctly depending upon the solar irradiance or solar insolation, So there are two major factors which decides the daily production. First one is the Azimuth angle(the angle the compass direction from which the sunlight is coming and other is Tilt angle (angle of orientation os solar panel) [4].

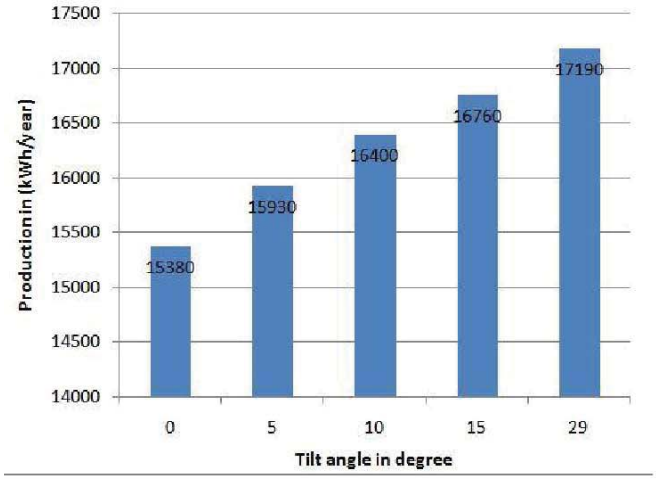

Fig. 4 Annual energy yield of 10kw solar v/s tilt angle

The production of electricity from a 10kw solar panel at various tilt angle is shown above. It is calculated using data from Indian Meteorological website and the above formula. It can be observed easily that maximum yield of power is 17,190 kWh and it is at 29◦ facing south [4].

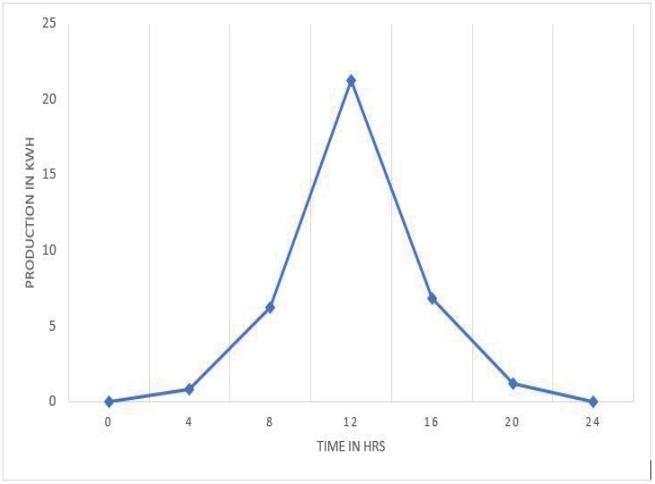

Fig. 5 Graph for production during various time in a day

The graph is drawn between energy production at various time of the day, basically in the morning time production is minimum and at afternoon it goes to maximum. Because the solar radiation is direct (perpendicular) on the panels, hence the production will be maximized [3].

4. Modes of charging

Basically there are three types of charger used based on their power ratings. Two of them are AC charger and one is DC charger. AC charger includes both residential and commercial which usually takes maximum time like 6 to 12 hours. DC fast charger is CHAdeMO type of charger which is very high power charger and it takes only 30 minutes to charge an EV from 0 to 80 percent [9].

The power capacity of the charger including the supply voltage and current is given in table 3.

EVSE Type	Power Supply	Charger Power	Charging time* (Approx.)
L1 AC Residential chargers	120/230VAC & 12 A to 16A (Single Phase)	1.44kW to 1.92kW	12Hours
L2 AC Commercial chargers	208 - 240VAC & 15 A - 80A (Single/ Split Phase)	3.1kW to 19.2kW	6 Hours
L3, DCFast Chargers	300 - 600VDC & (Max 400A) (Poly Phase)	120kW to 240kW	30 Minutes

Table. 3 Types of charger and its specifications

5. Financial performance

The initial investment was calculated as 14 lakhs, it includes various costs like solar panel, batteries, others components, as well as the costs of installation, execution. Total system cost breakdown is given in figure 5 which shows the panel cost maximum [8].

The amount energy produced by this system costs Rs 2.6/kWh and this totally less as compared with others source of electricity generation. But the maximum efficiency of solar panel is 25 percent. Various researches are underway, to increase the efficiency of solar cells. The final costs of the system include the depreciation costs, maintenance costs etc [8]. but in couple of years the whole initial investment is recovered and generation become free.

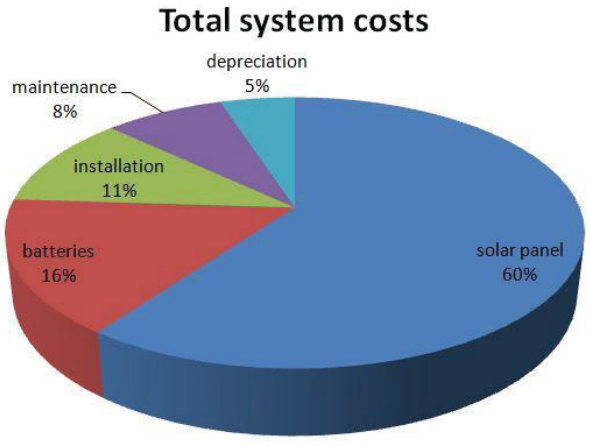

Fig. 6 Total system cost breakdown

Conclusion

After all the studies and description, we can say that if number of charging station will increase and specially the solar based EVST. Then there will be decrease in energy demand from the grid. Ultimately the carbon emission will reduce and pollution will be less. The energy gap

between demand and supply of electricity will be reduced and daily consumption of electricity will be provided to everyone [7]. As India is a developing country so it will help in growing the economy also, as number of charging station will increase, the demand for EV will also increase and more manufacturing units will open. It will create more number of job opportunities and strengthen the economy [5].

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