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Development of Photo Voltaic - Electric Bicycle Powered by Solar

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Abstract: In the past few years the investments in photovoltaic power plants have managed an exponential growth of power production. These plants are basically located near the cities or villages. The release of noxious chemicals because of combustion of petroleum is a serious threat to human beings and is now a worldwide problem. The paper analyzes photovoltaic systems as auxiliary power generators in electric vehicles (especially electric bicycles). It presents an idea to integrate the photovoltaic system in urban cities. Moreover, these vehicles are noiseless, pollution free and maintenance is less.
Keywords: Electric bicycle, photovoltaic plant, charging infrastructure, assumptions, annual output.

I. INTRODUCTION

In all the developed cities around the globe, during the last few decades the number of cars on road has increased a lot, resulting in huge traffic jams. The government has tried a lot to reduce these traffic jams by changing two-way traffic into one-way traffic as well as constructed new bridges and subways wherever possible. These infrastructures helped a lot in diminishing traffic but the environment was still impacted with the tailpipe emissions due to the large number of cars.

Electric vehicles have become an attractive alternative to internal combustion engine vehicles (ICEV), as a result of their benefits towards environment and the increasing prices of oil. Therefore, the development and enforcement of E-vehicles have become a focus of government in developed cities. The use of internal combustion engine vehicles is clearly responsible for the sudden climate changes of the environment, local air pollution and the decline of physical activities and obesity.[1]

A. Electric Bicycle

An electric bicycle famously known as E-bike is a bicycle with an attached integrated electric motor which can be used for the movement of the bike (propulsion). There are a vast variety of E-bikes available all around the globe consisting of a small motor to assist the bicycler’s pedal power to E-bikes that are more powerful in nature which has functionalities similar to moped style bikes. However, the above types of bikes retain the ability to be retained by the biker. Thus, they are not exactly electric motorcycles. E-bikes use rechargeable electric batteries and lighter variants can travel up to 25-32 km/hr. while the higher variants can gain a speed up to 45 km/hr. In countries like China the mopeds and small motorcycles are replaced with E- vehicles. In some markets like Germany, E- vehicles have gained huge popularity and also took a market share away from the conventional types of bikes.[3]

Table 1 shows the motor power output of E- vehicles in various countries according to their local laws:

Motor Power Output Of E-Vehicles

Country	Motor power output
Australia	200 W (currently tabling legislation to move to 250 W)
Canada	500 W
Europe	250 W
India	250 W
Japan	250 W
New Zealand	300 W
Singapore	200 W (note potential shift to 250 W in the near future)
United Kingdom	200 W in UK law overridden by 250 W in European legislation
United States of America	750 W

B. Charging Infrastructure

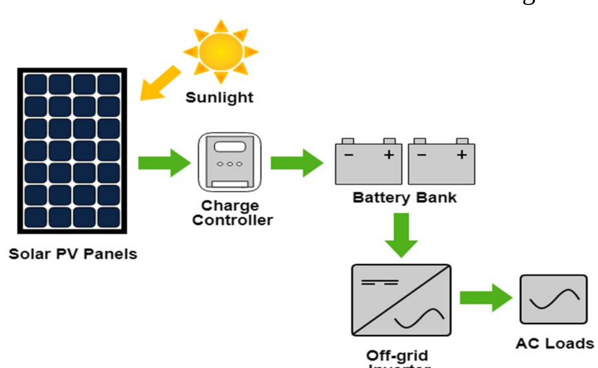
To cover the entire city, a charging infrastructure is to be created in order to fulfil the demands of people for travelling short distances as well as long distances. In the developed cities the availability of land for building this infrastructure is a serious problem. Therefore, a solution may be using an existing public network, in order to build this infrastructure. Such public network is depicted by tram station platforms, because of plenty number of platforms and the considerable area. Another advantage of these stations is that they are located in the centre of streets that eliminate the problem of photovoltaic panels (i.e. Shading). The charging infrastructure of tram stations has to be built modular in order to simplify its constructional work and maintenance.

A Tram Station In Dubai

The infrastructure consists of three systems, namely the operating system, consumer information system and the charging system. Among all these systems the charging system is of utmost importance and it is the fundamental element of charging infrastructure. Basically, the charging system is of two types slow charging system and fast charging system depending upon the time taken to be charged and the charging method. The slow charger basically supplies a power of 3-4kW to the electro voltaic power plant and the approximate time required for charging differs from 6-7hours. However, a fast charging system can supply an energy of 50kW while taking less than 30 min for completing the charging process. Thus, slow charging system is beneficial for charging procedure during night time.[1] for charging of electric bicycles a similar system can be used.

C. Working of Photo voltaic Power Plant

Solar photo voltaic system consists of cells that are used to convert sunlight in to electricity. The photo voltaic cell comprises of uni or bilayers of semi conducting material mostly silicon. When the rays of sun shines on the cell that generates an electric field across the layers causing electricity to flow. Greater the intensity of light more is the flow of electricity. Photo voltaic cells are referred in terms of the amount of energy generated in full sunlight; which is also known as kilowatt peak or kWp. The cell is the basic building block of solar photo voltaic technology. In this plant solar energy is collected in the form of sunlight and is converted to direct current (DC) electricity. An inverter can further convert this DC current into alternating current (AC).



Solar PV System

These photovoltaic power plants can produce any amount of energy as per requirement and also have a higher rate of efficiency.

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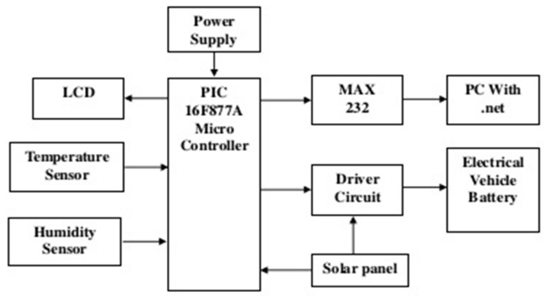
D. Charging System Configuration

The main power conversion system comprises of and AC to DC converter. The converter must have certain properties in order to be safe, secure as well as efficient while charging. Also, while designing such type of converters special attention is needed to be paid to the system optimization in terms of its size, weight, space, volume and cost. All the parts of this converter from semiconductors to heat sinks including passive filter must be designed in such a manner such that the system is optimized.

BLOCK DIAGRAM:



Charging system of electric vehicles

E. Multiple charging Stations

The requirements for multiple charging system are initially same as that of single charging system. Apart from infrastructure for communication between smart stations, if applicable. Each charging station must be connected to a separate branch circuit, and the installation must have the following requirements:

1) One breaker for each station
2) One distribution panel for each station
3) One branch circuit for each station

F. Photovoltaic System Estimation

Installing photo voltaic systems in developed cities is predictably effective as well as efficient. But as the population is increasing exponentially the density of sunlight in cities is getting less because of the buildings constructed all around. The photo voltaic system needs large amount of space for generating the required amount of electricity. Basically, there are no empty space available in developed cities for installing such plants.[4]

According to the European scientists, Lehman and peter used a data set of buildings in Germany, with an assumed 13.4m^2 for 1kWp of rooftop area and 7.1m^2 area for 1kWp of vacant land suitable for photo voltaic plant.

G. Assumptions of Photo Voltaic Installations

There are basically three assumptions for photo voltaic installations for getting required potential. First pattern is to use 100% of rooftops with an angle tilt of 0 degrees (7.1m^2 area for 1kWp). Second pattern is to use 100% of roof with all the photo voltaic installed in south direction with an angle tilt of 25 degrees (13.4m^2 for 1kWp). Third pattern is to make an arrangement of these photovoltaic installed in east and west direction of all the tram stations as most of the developed cities have tram stations (10.5m^2 for 1kWp). The available surface area for installing photo voltaic system will be determined by all the tram stations present in a city. On an average each station is about 35m long and width is 2m. each station would have at least two passenger platforms. Therefore, the available surface can be calculated by:

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$S_a=2*N*S_s$
Where,
S_a= total surface available
N= no. of stations available
S_s= surface of the platforms
The installed power for photo voltaic system can be calculated by:
$Z= S_a/X$
Where,
Z= installed power
S_a=total surface available
X= surface required for installing 1kWp

H. Results of Estimation

The estimation of assumption will be close to the actual potential produced by the photovoltaic system.[6]

Assumption	1	2	3
Total area [m²]	66,080		
Surface required for 1 kWp [m²]	7.1	13,4	10,5
Possible capacity [kWp]	9,307.04	4,931.34	6,293.34
Annual output energy [MWh]	9662,56	5118,73	6532,48

I. Estimation of Annual Output Energy

To travel one kilometer by electric bicycle approximately 5-15 watt hours of energy is required. The electric motor installed in an electric bicycle is 250W. one photo voltaic system can charge up to 25000 electric bicycles. The photo voltaic system is grid connected thus energy for charging is available all the time. With the installation of photo voltaic system approximately 2.7 tons of carbon dioxide (CO_2) can be reduced.

II. CONCLUSION

The paper presented represents an idea of bringing photovoltaic systems in developed cities at a large scale. Once brought in to the cities the photo voltaic system and the charging system together will encourage the people of the city to buy electric vehicles and use them instead of cars, the pollution will reduce to a large extent also the problem of global warming will be reduced. This paper shows the integration of photo voltaic system can possibly solve the daily problems of public and private transport in the developed cities.

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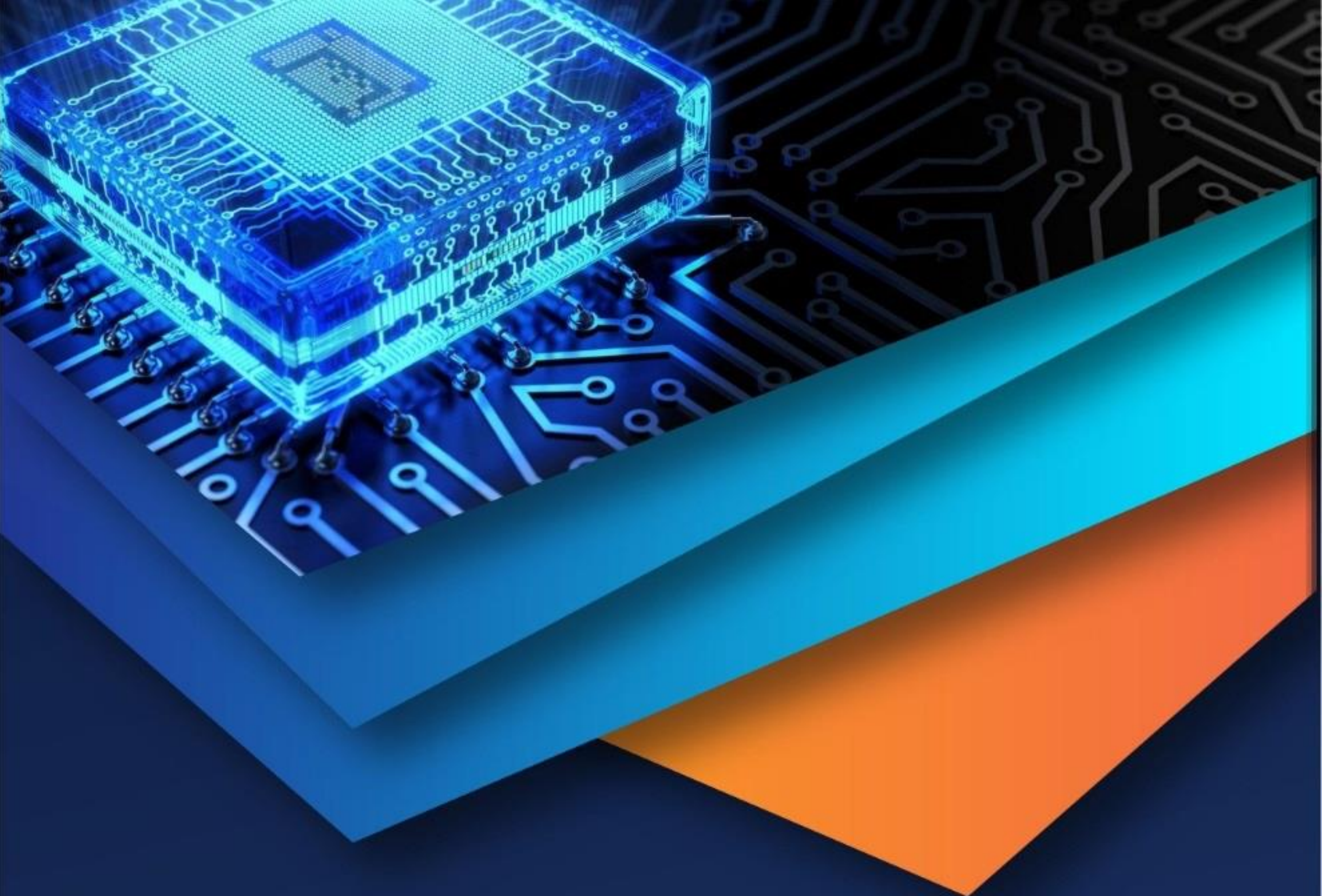

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