

Green Parking Lots for Energy plus Human Settlements



Ar. Chetan Verma, Jitendra Singh, Alok Ranjan

Abstract: Energy is the basic need for any development programme. Growing energy demands are putting the non renewable energy sources at risk of extinction. One of the major energy consuming sector is automobiles, traffic in urban settlements. Now a days battery operated vehicles are on road for public and private transportation which are an alternative to conventional fuel vehicle systems of petrol, diesel, gas oil. But the issue of fuel or we can say charging the battery operated vehicles remains constant and a challenge for urban transportation systems. This paper is focused to design approach of such parking lots and road side parking slots which are not only space for vehicle parking but also charges the vehicle while it is parked. This kind of refueling system will use the idle time of the vehicle and will reduce the requirement of refueling stations. Such system will save the time of the car owner for waiting at refueling or charging station. The methodology of this approach consists of using the renewable sources of energy such as solar, wind energy and distributed energy generation systems so that such systems can be used in designing energy plus human settlements. The distributed energy generation system will reduce the need of major electric substations to handle the generated electricity..

Keywords : renewable energy, electric vehicles, energy plus, smart refueling

I. INTRODUCTION

Considering living beings thermal comfort is one of the basic things to live, work & relax. Heating and cooling are two most used phenomenon to achieve such conditions depending upon the climatic conditions. Parallel to this increasing technological dependence in process of growth is a matter of comfort and luxury but it is coming at the cost of limited non renewable sources of energy, which somewhere is an threat to the growth of human race. Hence we can easily say that energy in multiple forms as fuel is required in this process of growth and development.

Automobile sector consisting of multiple transportation activities is also one of the largest consumer of energy. Transportation systems (passengers & goods) is considered to be the backbone of any settlement to develop.

People living in every settlement have daily needs or travelling and transferring goods from one place to another and multiple types of vehicles are used to meet such demands of the people[1]. Vehicles are of different types and class such as two-wheeler, three-wheeler, four-wheeler differentiated in different classes according to their passenger and goods carrying capacities. Parallel to there use which requires fuel vehicles also needed to be safely handled and parked which further requires a lot of space depending upon there size. However some heavy vehicles such as earth movers are exception but a range of small and mid sized vehicles are now running on battery operated systems which can be recharged or refueled using renewable sources of energy. Such as e-scooters, e-karts, passenger cars, bus and small trucks of limited loading capacity. Parking lots are such spaces which are designed specially for vehicles to park for short and long time intervals. Night parking, idle parking, hourly charges based roadside parking and there are many more concepts ranging from individual parking lots in residences up to multilevel parking lots for urban nodal places. Now a days to overcome the parking space crisis in urbanized places multilevel parking lots are much preferred but upcoming electric vehicle technology is giving us another challenge of refueling or recharging the vehicles as the time consumption for recharging one battery operated vehicle is much more then the corresponding traditional fuel operated model. To overcome such crisis such energy generating or green parking lots are a major support not only to the transportation system but it can also be a role player in futuristic energy plus human settlements. Energy plus human settlements are such settlements which are capable of generating more energy then the consumption over an specific interval of time using renewable resources of energy. Green parking lots are designed to be as efficient as any other parking lot additionally they are capable to charge battery operated vehicles in idle time, from energy generated using renewable energy sources.

II. ELECTRIC VEHICLES

A. Different types of electric vehicles

Considering a settlement the types of vehicles used in majority are scooters and cars for private use and auto, cars and buses for public transport system. However up to a certain load limits some good transporting four wheeler are also used that runs on battery. All of them have different types of motors and battery capacities and hence have different time requirements for recharging. Charging of such vehicles also depends upon the available mode of charging weather they have normal or fast charging mode and equipment.

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On the difference of engine systems there are three types of electric vehicles explained below[2];BEV, battery electric vehicles, these vehicles are solely dependent on a battery system and can be totally green vehicles if charged from electricity generated from renewable sources of energy. These vehicles are considered to be the best for local and short route trips.HEV, hybrid electric vehicles, these vehicles are comprised of battery and traditional fuel system engine and runs either on battery or on fossil fuel or on both as required. Since these vehicles use certain percentage of fossil fuels hence can not be considered totally green at any stage.PHEV, plug-in hybrid electric vehicles, these vehicles are similar to HEV concept except the battery used is of much higher capacity and are good for longer trips and goods transportation from one city to another.Comparing the concepts of the different types of electric vehicles BEV are the most preferred types to be a part of transportation system of an futuristic energy plus human settlement.

B. Advantages of battery electric vehicles (BEV)

The operating cost of BEV is comparatively cheaper compared to other electric vehicles and traditional fuel powered vehicles. Additionally for urban settlements driving experience of BEV is better due immediate acceleration with limited top speed to easy start stop.BEV are totally silent and the tail pipe carbon emission is zero hence these vehicles are environment friendly and helps reducing noise and air pollution simultaneously.In BEV talking about fuel emission reduction can be achieved up to 100 % if they are charged on electricity generated from renewable sources.

C. Disadvantages of battery electric vehicles (BEV)

Due to the low number production the unit price is high but this will come down when the use of BEV will overcome the traditional vehicles.Another low side of BEV are number recharging stations and high charging time. Normal charging system take from 3 - 12 hours of charging time or overnight charging and even the fast charging is also of minimum 25 - 90 minutes which is much more time consuming then refueling traditional vehicles. Green parking lots are a solution for such disadvantages.

III. RENEWABLE ENERGY GENERATION

Although there are multiple sources of renewable energy generation but considering hot and dry climatic regions the most preferred resources are sun and wind, being hot and dry a region is abundant in solar energy generation and its windy too throughout the day and night. Using elements of energy generation from these two sources will be the most viable.

A. Solar Energy

Sun is an infinite source of energy and in hot and dry regions its available in abundance. Such regions have averagely 5 to 7 efficient hours of sun radiations that can be converted in usable form of energy. Harnessing sun radiation is possible using PV collectors.PV collectors can be used in multiple ways such as flat plate collectors, focused or concentrated collectors (cylindrical trough solar collectors) further the collected radiations can be used for generating electricity or heating up water, cooking food etc.

In urban areas PV collectors are best for harnessing solar energy. Although it requires space hence to rooftops and south face of the buildings (multilevel car parks) can be used to install solar panels and solar films on the glass facades. On surface parking systems sunshades comprised to PV plates on top are of efficient use[3].

Counting on limitations then the infrastructure is of no use at night and additionally on rainy and cloudy days also. But considering hot and dry climates the cloudy days per years are less and correspondingly less rain.

B. Wind Energy

Wind is also an renewable source of energy. Considering hot and dry climates the wind flow is good for harnessing energy using technology.

Wind mills are one of the most traditional technologies to harness wind energy and convert it into usable form of energy. Still used in many dry and desert areas of hot and dry climatic regions. Besides the traditional design blade less wind turbine in different sizes are also available which consumes less space and are comparatively more efficient as theses designs can also work in less wind speed.

Such instruments can efficiently harness wind energy to electricity during day and night hours too and can charge the vehicles parked in the parking areas or the electricity can be stored in the batteries and can be used next day for charging vehicles in idle time.

C. Other viable methods of energy generation

There are many forms of energy around us and we can convert them into usable form using different methods. Kinetic energy is one of such that can be converted by using tiles for pedestrian walkways or speed breakers that are installed on roads to maintain speed limit in the city can also convert the kinetic energy from moving vehicular traffic into usable form. This energy can be stored in batteries by installing collecting and charging units on road sides and can be useful for short term road side charging for battery operated vehicles.

IV. VEHICLE PARKING CUM CHARGING LOTS

The current model of existing carports around the world is composite. Many public and private properties are installed with carports but due to the less use of electric cars the energy generated by the carport is used by the building adjacent to the parking converted carport. However some bays are installed with charging units. But the existing cases of car ports are only comprised of solar energy option.Green parking lot concept is dedicated for vehicle charging using multiple renewable source of energy meeting the end used demands. It targets the different types of parking lots of an human settlement. Parking lots of official buildings where the idle car parking time is as much as of the office working hrs per day will be comprised of standard charging ports. Shopping mall car parks which have short term parking will be comprised of fast charging ports. Roadside car parking spots owned by adjacent super markets, showrooms and recreational areas will be comprised of rapid charging ports as the time interval of parking at such spots is very short.

Considering multilevel parking lots then mostly for energy generation they are dependent on roof tops and facade facing the direction of sun regarding solar energy and additionally wind mills can be installed in the building structure during the designing part. Talking about surface parking then it is not only about energy generation but shade for the vehicles is also an important to be considered. There are multiple types of engineered structures for surface parking dependent on solar energy;



Fig. 1. Monopitch canopy T-Frame single row structure



Fig. 2. Monopitch canopy V-Frame single row structure

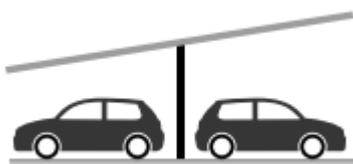


Fig. 3. Monopitch canopy T-Frame double row structure



Fig. 4. Monopitch canopy V-Frame double row structure



Fig. 5. Duopitch canopy T-Frame double row structure



Fig. 6. Duopitch canopy V-Frame double row structure



Fig. 7. Portal frame canopy barrel arch multiple row structure



Fig. 8.. Portal frame canopy beam roof multiple row structure

Above shown are efficient possible ways of making parking systems installed with rooftop solar panels to generated usable energy and provide it for charging of the parked BEV. However as shown in fig. 5 the most efficient of all is duopitch canopy V-frame double row structure as it has ample space in between the V - shaped structures for charging system equipment to install[4].

V. CASE STUDIES

Some related concepts exists around with different usability. Multiple companies are working on it. Some cases are as follows;

- GARDEN CITY SHOPPING MALL, NAIROBI, KENYA



Fig. 9. Rooftop parking of garden city shopping mall

It is situated on thika superhighway Nairobi in an mix land use project of 32 acres. On the top storey of the mall solar century has developed an carport system of 454 parking bays with 858 KW that is enough for supplying power to 550 urban homes in Nairobi. With 3300 solar panels it generates 1256 MWh electricity per year and cuts 745 tonnes of carbon emission per year. The energy generated is used in the mall by retail tenants and other activities of mall running on electricity[5].

- HOFFENHEIM FOOTBALL STADIUM, SINSHEIM, GERMANY

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Fig. 10 . Parking lot of Boffenheim football stadium

One of the largest carport system in EU completed in 2014 by Wiron it is an 1MW capacity solar power system system with 4025 solar panels which not only generates 66% of the energy demands of the stadium per year but also provide shade for 450 parking bays[5].

VI. EFFECTIVE APPLICATIONS

Considering a futuristic energy plus human settlement an efficient transportation system will play a key role as it makes day to day tasks easier. Comfort is not only required in private transportation vehicle but also for public and goods transportation. For effective use of green parking lots major application to support the transportation system are: Converting the idle and night parking for public and private buses into green parking lots so that it will be easier to charge buses (BEV) during the non working and night hours. Related infrastructure will be such as city bus terminals and bus depots. Another major form of transportation is goods where different types trucks are used. Hence installing an rapid charging system in truck terminal or idle parking lots of trucks will help internal and nearby goods transportation to be operated on BEV. Taxi stations are also one of the major role players in transit system of a city. However the flexibility of time with cabs (three and four wheeled vehicles) is more then the other public transportation systems like buses but also they require less time for recharging then heavier vehicles. Hence installing fast and rapid charging stations running on renewable resources will be a plus for energy plus human settlements. Private car user of a city have different schedules of weekdays and weekends which may include office trips, holiday trips, local city trips hence this section of users requires more flexibility then others. Hence green parking are required near official hubs, on roadside parking spots, roadside super market parking areas, individual residences. Two wheeled vehicles are major part of transportation system specially inside the city. Additionally two wheeled vehicles take less time to recharge in comparison to the heavier vehicles. However they are majorly individually owned and are used for short distance and crowded places. Two wheeled vehicle taxi concepts are new to the market but is growing fast as they results in a cheaper way of transportation for individual travelers in short distances. Hence installing green parking spots with fast and rapid charging systems in different locations of a city will help this mode of transportation effectively. The additional benefit of this system is reduced traffic on the roads.

Another practical application of green parking lots in the parking lots of public transportation systems such as rail, metro rail, rapid rail, intercity bus terminals as a lot of commuters travel a part of their daily routine journey with

private vehicle and for the other part of journey they commute by public transportation. Hence installing green parking lots for such places will provide flexibility to commuters to recharge their BEV (two or four wheeled generally) to be more time efficient. Besides all above to help passenger and goods transportation to nearby and adjacent cities to promote trade and business green recharging stations should be installed. All this will not only help a city to be zero carbon emission but also a step towards energy plus human settlement by shifting the total transportation needs on renewable energy.

VII. ECONOMIC VIABILITY

Going green is always economic viable. In last two to three decades world has witnesses a lot of changes regarding use of traditional fuel towards the greener options. Such as introduction of CNG and PNG for domestic and commercial use but future is not only about reducing carbon footprints but it also requires to mark its independence from all kinds of traditional fuels to be sustainable. Green parking lots and green parking spots involve a capital cost for related infrastructure but after that the fuel used is free and abundant (wind & sun). Another bright fact is that BEV have no carbon emission but also they are totally silent reducing noise pollution. Sound proofing and air proofing of the vehicles involves a lost of costing and the requirement is rising due to rising pollution only. Using BEV will solve this and green parking lots will help BEV to establish as major caterer of transportation needs of all types. However the current prices of BEV are high but if they become in majority part of system the prices will automatically reduced. Another factor that hits the economics of this system is unit price of electricity for vehicle charging in green parking lots. Although the charging of vehicles requires a capital cost for infrastructure development but due to good quality, life span and dependence on renewable sources of energy of the infrastructure it results in cheaper options. Additionally depending upon the type of charging used by the vehicle owner a tariff are can be setup to revive the infrastructure cost upto some extent. Multiple charging options such as standard / normal charging with minimal rates per unit, fast charge with rate above the standard charging and rapid charging with highest user suitable rates per unit[6]. All above factors clearly states that this initiative is not only economically viable but also its is acceptable for the future of healthy living.

VIII. SOCIAL VIABILITY

Social acceptance of any idea and model is very important accept as the development of for society only. Current model of transportation dependent on fossil fuels in not only depleting the limited reserves of fossils but the carbon emission due to its use is also depleting our environment and individual health. Hence it will be strongly acceptable by each individuals of society as they are getting benefits of a healthy environment for themselves and coming generations in terms of reduced carbon content in breathing air, reduced noise pollution, no waste of time in ques at fuel stations, less mechanical maintaining requirements of the vehicles, no requirement of pollution check of the vehicle[7].

All such factors proves that the social viability of green parking lots as an elements for development of energy plus human settlements.

IX. ANALYTICAL RESULTS

Green parking lots are not fully new and unique concept but it is a multiplication of current running models such as carports. Some countries in European, Asian and even in African continents have some small scale working models in use by public of this concept but they are generally owned by private ventures hence are of use to limited group of people in the society or class. But green parking lot system is not having such limitations as it is for energy part of society and proposed to be designed in all such parts of the city which are accessible by all. Comparing to the solar carport systems as discussed in the case studies section earlier the green parking lots will be exclusively designed for charging the vehicles however the excess left over energy can be used for supply to the existing structures as per requirement to be in energy plus category. This will clearly provide the flexibility of refueling or recharging at idle time to the user and will also save the time and energy of the user that is going to be wasted in waiting while standing in the long ques at refueling or recharging stations. Also this will eliminate the need of exclusive recharging stations specially inside the city saving the multiple chunks of land which is another important resource.

X. CONCLUSION

Green parking lots are will not only be a solution for smoother transportation system but they will also serve as a solution for air and noise pollution caused by transportation sector. Its application will save user time consumption on refueling station. Since the basic fuel is generated using renewable sources of energy hence it will slowly eliminate the requirement of fossil based fuels for transportation sector leading to an energy plus human settlement.

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