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Implementation of Efficient Plug-in Hybrid Vehicle Charging

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ABSTRACT: Renewable energy sources are need of our future. The vehicles depend on fossil fuels for their daily trips; hence problems will arise in future as they are limited. There is a requirement to preserve the same. Plug-in hybrid vehicle (PHEV) is future of our transportation system which will alleviate the use of fossil fuel to a great extent. Plug-in hybrid vehicle strategy is in demand as it relies less on combustion fuels. In this paper a solar based charging station idea is presented. There is on-going research to increase the efficiency of solar panel. It is difficult to increase the efficiency by changing the internal structure, therefore, a new technique called externally tarp the light is used to increase the efficiency of solar panel. A parabolic concentrator is designed which is then 3D printed. It reflects the photons that are incident on the surface and thus with retro-reflection efficiency gets increased. For an instance the vehicle's battery is at threshold then to serve it mobile chargers (MC) are used. So here we have developed an android application that can alleviate range anxiety problem of PHEV users. It has various features like call the Mobile Servers (MS), range prediction with current battery status and slot booking. The mobile server relies on queuing technique that find out design parameter for such mobile charging system. Here, the design parameter is NJN (next-job-next) technique. In NJN, MC provides service to nearest PHEV when done with the recent one. As the charging stations are limited there is need to book the same. So, the application helps the driver to do the same. So, our main motto is to reduce range anxiety problem of PHEV users and preserve the environment by reducing harmful emissions from vehicles.

KEYWORDS: Battery charging, 3D printed parabolic concentrator, Queuing theory, Mobile application, slots booking, Plug-in Hybrid Vehicle.

I.INTRODUCTION

Currently, demands for oil consumption have increased tremendously in transportation sector. Statistically we analyse that, with the on-going rate of uncovering of new reserves of oil and the on-going consumption rate, by 2049 there will be depletion of reserves of oil [1]. This is mainly due to increase in number of vehicles sourced by internal combustion engines. The whopping usage of Internal Combustion Engine (ICE) vehicles has staggeringly lent to pollute the developed and under developed cities [2]. The environmental issue of the global warming and greenhouse effects are caused due to vehicle emissions; agencies ruled by government have developed confining standards for consumption of fuel and its emissions [3]. The Electric Vehicles (EVs) are likely to be complete solution to deal with global warming and energy crises issues. Electric vehicles help to rejuvenate the calibre of cities life as it does not emit harmful gases and provide peaceful drive [2]. For small trips and when there is more breaks in journey, electric vehicles can remit characteristics same as an ICE vehicle and moreover it is at less cost when we compare it with normal fuel based vehicles while driving on the road [2,4].

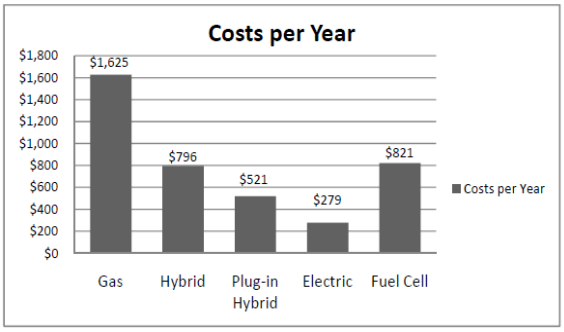

Figure 1: Annual operational cost comparison for different vehicle architectures.

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As reported in [3], 70% of the urban population covers less than 100km in their daily journey. This engenders pollution that degrades an environmental condition. For daily journey electric vehicle would be the best option. The reach of electric vehicles will increase when there will be regular start and stop in our journey. Thus, zero emission transportation would be provided by electric vehicles.

Figure 1 shows a comparison of annual operational costs among different vehicle architectures [4].The terrible unravelling of vehicle engineering, as shown in Figure 2, the design became much complicated than actually required for obtaining required the achievement in its functionality[5].

The electric vehicles restricted range problem, can be overcome with the help of Plug-in hybrid electric vehicle (PHEV). A difference between PHEV and hybrid electric vehicle is that the storage part i.e. battery can be recharged from the grid [6]. The environmental problems and problems related to range gets reduced with the help of PHEV but the load of electricity will increase on grid. So, its demand will also increase. Hence, to lessen this problematic situation a solar panel permanently mounted on charging station would be perfect solution. Still there is a problem related to efficiency of solar panel that's why externally light trapping design is made which will collect the sun energy towards the solar panel. In this way without altering internal design of solar panel or cell we can increase solar panel efficiency. The parabolic concentrator which is 3D printed is used to for this purpose.

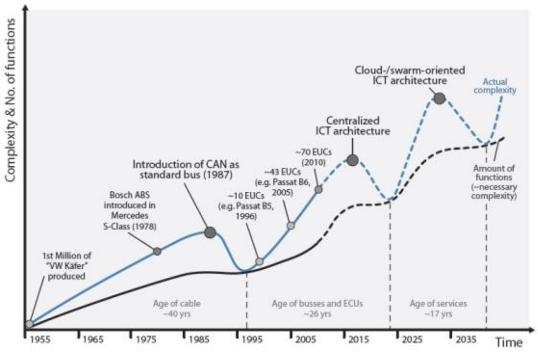

Figure 2: Evolution of complexity in the automotive domain.

The renewable energy sources cannot completely help to lessen the range anxiety problem. The battery can be charged externally called plug-in charging. Plug-in charging can be categorized into following levels: 1, 2 and 3. We can set up level-1 charger in plug available in house but power it provides is very less. Moreover, it took 10-12 hours to charge the battery. Level-2 charger provides more power than level-1 but took 8-10 hours to charge the battery. The most affordable level-3 charger is a fast DC charger which provides power at high level and charging time is also reduced to 20 min. Therefore, mostly users prefer level-3 charging system as time required is very less.

We developed mobile charging strategy for battery recharge. We propose queuing approach to model mobile charging technique. The strategy used here to perform the mobile charging operation is NJN which provide service to the mobile client. This strategy is best instead of First-come-first-serve (FCFS).

II. LITERATURE REVIEW

It considers a network Vehicles play an important role in our day-to-day life. There is ongoing research on how we can reduce harmful gases exiting from vehicles along with cost reduction of car so that consumer can buy it easily. The price of hybrid vehicle is more than traditional one but it gives rise to environmental pollution. The problem of range anxiety inhibit the consumer from buying electric car i.e. a person will be in tragedy if battery runs of its charge, as he will be unable to complete his journey. Let's watch various strategies with which battery can be charged.

The author proposed an agent-based model that considers demographic and spatial factors to investigate the PHEV charging effects [7]. PHEV users are considered as agents who make their daily trip plan. The PHEV users need to pay more amounts during peak hours and less during off time. Fast charging is its advantage but grid load increases.

The author studied the effect of charging a plug-in hybrid vehicle with the help of utilities and grids [8]. This paper presents the situation which converts LDV to PHEV and studied its impacts as electricity supplants gasoline. It ends with a discussion about how grid gets affected due to PHEV load.

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The authors in [9] present the results of grid charges. It concludes that PHEV use would increase where prices of electricity would be less. Pricing rate would be affected by time of the day.

The authors in [10] present the electric vehicle's range anxiety situation. The authors in [11] propose an intelligent solar ecosystem for electric vehicles. A master controller will be required for the solar stations that will help an electric vehicle to lessen impact on the grid at the same time reducing the harmful emissions from vehicles. Load on grid is reduced but communication overhead is increased.

The author in [12] presents the concept of charging while driving on the road. Electric vehicles (EVs) can be charged wirelessly with the use of Contactless Power Transfer (CPT) systems. It is installed under the road, but the disadvantage is that each primary winding needs an inverter in order to generate the required high frequency AC current supply and practical implementation can hardly done.

The techniques mentioned above either consider home charging or grid charging. One more approach is the mobile charger (MC). It follows queuing theory concept to service the charge request. Now let's have a look on how to increase efficiency of solar cell.

The performance of solar cells which are thick can be increased by reducing its thickness provided absorptance remains constant. Thin solar cells absorptance is very high so lots of efforts have been done to obtain the same by performing certain changes of the solar cell surface to get the light trap internally [13, 14].

For nano-crystalline silicon the challenging part is the maturity of a solar cell on top of a textured scattering surface [15-17] while effectiveness of texturing is less for organic solar cells [18]. The full theoretical capability of internal light trapping is therefore troublesome task for solar cells methods [19] and hence there is a requirement for more efficient light trapping methods.

We developed an external light trap method that will replace internal trap methods more effectively without altering any textured calibre of solar cells [20]. 3D printed large concentrator arrays will lessen the want of internal trapping providing more efficiency than previous work and even cost effective.

III. PROPOSED SYSTEM

The proposed system is developed to alleviate need of fossil fuels with an efficient approach to charge vehicle with solar energy and provide assistance to the vehicle. The proposed system is divided into following parts:

a) Sun energy capturing module
b) Mobile charging
c) Slot booking
d) System overview

A. Sun energy capturing module

We are using parabolic concentrator which is 3D printed for externally trapping of light. This will be then mounted on solar panel. We can place concentrator array on solar cell to trap light more efficiently. It reduces the complexity and cost of implementation of single concentrator. Thus, we can have more energy from same panel. We proposed several designs for concentrator array like a square, hexagonal and circular to increase EQE.

B. Mobile charging

We can't totally rely on sun energy. A mobile charging approach is advised to charge the battery. It is discovered based on queuing theory and utilizes NJN (nearest-job-next) based strategy to serve PHEV owners. The mobile server will carry out the request depending upon NJN technique i.e. it will first provide service to nearest user then after its charging is done it will serve the next user as scheduled by NJN strategy.

C. Slot booking

We can book charging station slot if required. It searches for nearby charging station and book slots accordingly.

D. System overview

The proposed system is basically solar based charging station as shown in Figure 3. The concentrator is attached to the solar panel. In our circuit, ARM7 controller is used which operates the relay which acts as a station slot and the battery bank status and temperature is displayed on LCD. We have developed an android application for range prediction it can travel with current battery status. If the battery status is less then we can send the notification to the server which contains information regarding vehicles and their location. The mobile server receives the requests from vehicle users and evolves serving strategy. This is known as mobile charging system. Moreover, we can book the slot of charging station with the help of android application

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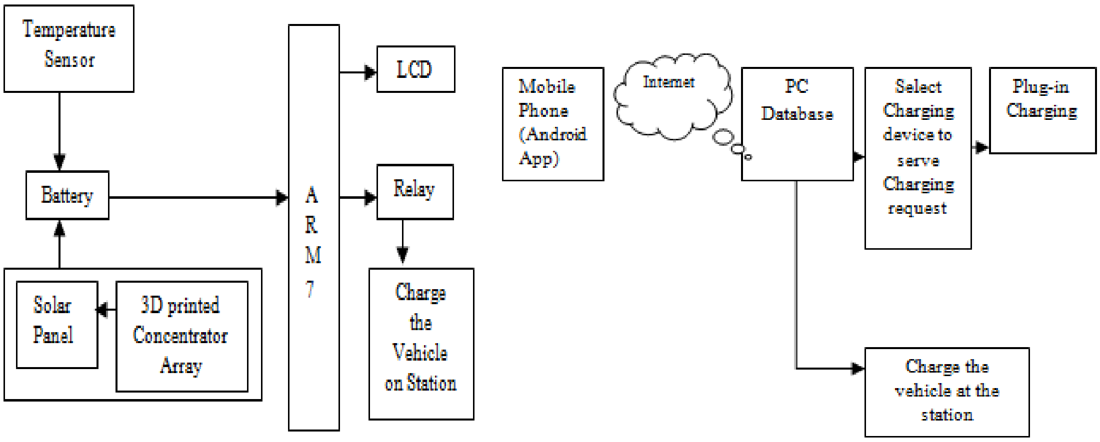

Figure 3: Proposed System.

Hardware implementation of the proposed system is as shown in figure 4.

Figure 4: Hardware implementation.

IV. MOBILE APPLICATION

The android application is developed to support PHEV user against range anxiety problem. The android application starts with login form and if the user is not registered yet he can register his PHEV vehicle. The registered user will be then able to access various functionalities of the application by entering its username and password. The different functionalities of the application from the user side are as follows:

- Range Prediction
- Search nearby stations
- Reservation of station
- Call the mobile charger

The same application is used to support server to fulfil the requirement of the user. The application starts with admin login page. The admin will observe the booking list and call list of the user. So mainly admin side can serve two purposes:

- Serve the call users
- Charge the user battery available at the station as per booking

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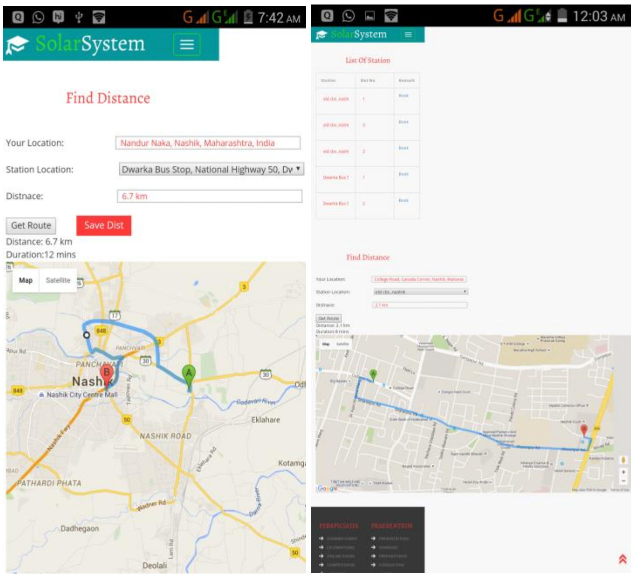
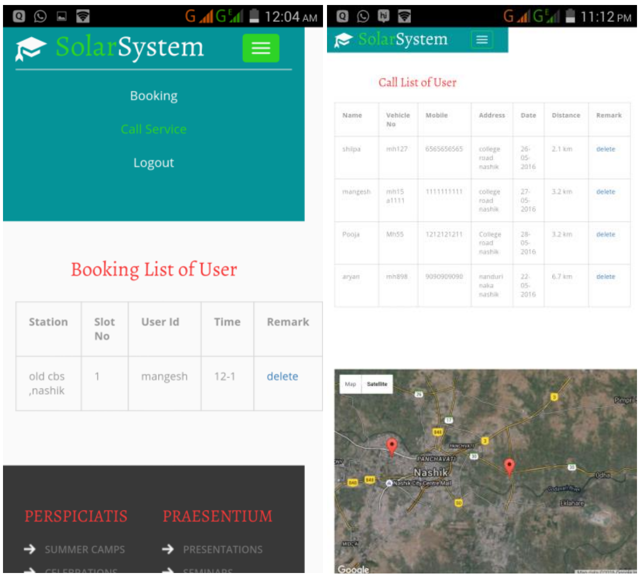
The user has to enter its current battery status and the application will display the range it can travel with that battery state. The user has to enter its current location then the application will display the nearest station from its current location along with its distance on google map as shown in Figure. 5(a).

The user can opt for either book the slot or call the mobile server. For slot booking user can observe the list of station and which is the nearest slot it can book as shown in Figure 5(b). Moreover, the user if feels that it cannot travel even that distance with current battery status he can call the nearest mobile server.



(a) (b)

Figure 5: Screenshot of application view (a) Calculate distance of nearest server (b) Slot booking of the nearest server.



(a) (b)

Figure 6: Screenshot of server side view (a) Display of bookin list of user (b) Display of calling list of user and which one to serve first.

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V.CONCLUSION

Thus, we have studied various charging techniques and strategy for charging of plug-in hybrid vehicle. Also, we have studied strategy required to improve solar efficiency with the help of external light trap. Thus it provides unique technology to serve battery refilling. An NJN serving strategy is developed for a mobile charging system. In such a system, the charging requests from PHEVs are demonstrated through a Poisson distribution. In an NJN serving strategy, the MC provides service to the nearest PHEV user when it is over with its current request. Several possible designs have been proposed for a concentrator array that can be attached to solar panel. Thus, square, hexagonal and circular parabolic concentrators considered to improve EQE of solar cell. We can book charging slot hence providing an efficient way to get rid of range anxiety problem and reduce harmful emissions of gases that often occur in ICE vehicles.

VI. ACKNOWLEDGMENT

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