Optimal Scheduling of Plugin Electric Vehicles Considering Seasonal Uncertainty

Team EcoOptimizers

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ABSTRACT: In the era of globalization, Electric Vehicle (EV) smart charging is grabbing attention because it may put impact on the distribution network. This smart charging includes the coordination of Grid to Vehicle (G2V) and Vehicle to Grid (V2G). This scheduling is strongly correlated with the EV driving cycles, which includes daily mileage of EV, its each trip length for rides, its All-Electric Range, Battery capacity and so on. How the battery capacity of EV highly dependent on the specific density of the battery. This may differ due to the change in ambient temperature. Hence, it is very obvious that due to the seasonal changes, the battery may behave in different manner. Hence, the scheduling pattern for each EV may differ. In this paper, the variation of the charging coordination and its related variation in cost of charging has been observed. Moreover, to optimize the cost of charging, a recent soft computing technique has been applied. Later, a general conclusion has been made regarding the selection of season for better charging coordination

INTRODUCTION & MOTIVATION

- **Global warming is a significant issue today, largely driven by air pollution.**
- **A major contributor to air pollution is the use of internal combustion engine (ICE) vehicles.**
- **As a result, the electrification of automobiles has become a popular solution.**
- **However, while electric vehicles (EVs) are gaining popularity, the charging strategies are not applied to vehicles properly.**
- **So we have tried to analyse different charging strategies (considering G2V and V2G) for vehicles such that the owner of the car as well as the owner of the vehicle can benefit from it.**
- **Along with this we have studied different driving cycle pattern in different seasons and used it for optimal scheduling.**

OBJECTIVES

- **To study the driving cycle pattern of EVs in different seasons and analyse in which season optimal scheduling can be done more effectively**
- **To analyse which type of EVs are more suitable for Optimal scheduling.**

MATHEMATICAL MODELING

1)Charging Cost (objective function)

$$\min(Cost_{charge})=\sum_{t=1}^{T}\left(\sum_{k=1}^{N}(C_k^t - D_k^t)\cdot r_{\{PEV,k\}}\cdot RTP(t)\right) \quad (1)$$

where C- charging rate, D-discharging rate, RTP=Real Time Price

2)Battery Degradation Cost

$$Cost_{bat}=\sum_{K=1}^{N} c_{\{b,k\}}\, E_{\{b,k\}} + c_L)\cdot \frac{E_{\{dis,k\}}}{L_C E_{\{b,k\}} DOD} \quad (2)$$

where c=cost of battery per kWh for Kth PEV, E=Total energy discharged by Kth PEV, DOD=depth of charge , L=Battery Lifecycle at a particular DOD

3)Total Cost

$$Cost_{total}=Cost_{charge}+Cost_{bat} \quad (3)$$

$$Cost_{charge}=Cost_{V2G}+Cost_{G2V} \quad (4)$$

INPUT DATA (ALL THE DRIVING CYCLES FOLLOW NORMAL DISTRIBUTION [2])

- **TEST CASE 1:Scheduling with more HIGHER battery capacity. (BEV=50%, PHEV 40=30%, PHEV 30=20%)**
- **TEST CASE 2:Scheduling with more LOWER battery capacity.**
  (BEV=20%, PHEV 40=30%, PHEV 30=50%)

THE DYNAMIC TARIFF IS FETCHED FROM [1], WHERE AT 30 mins interval the price is changing

OUTPUT DATA

Seasons	HBC	LBC
Summer	-1.3511	2.2226
Monsoon	-1.2108	0.1271
Winter	-3.5168	1.366

RESULTS & DISCUSSION

FOR SUMMER:

Fig. 1a. Energy Exchange of HBC set of vehicles for 24 hrs

Fig. 1b. Energy Exchange of LBC set of vehicles for 24 hrs.

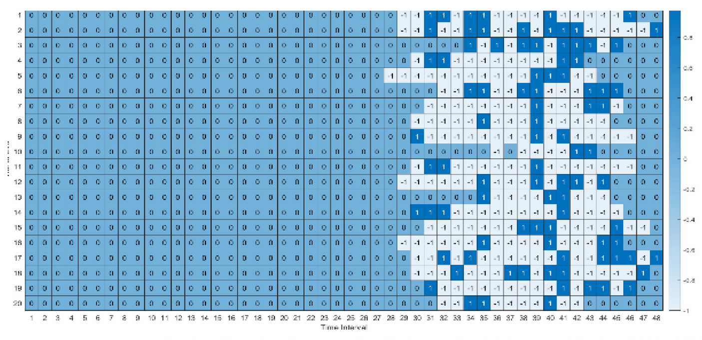


Fig. 2a. Charging Strategy for HBC set of vehicles considering G2V + V2G

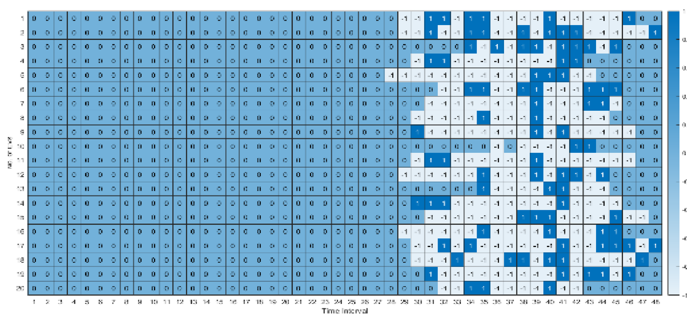


Fig. 2b. Charging Strategy for LBC set of vehicles considering G2V + V2G

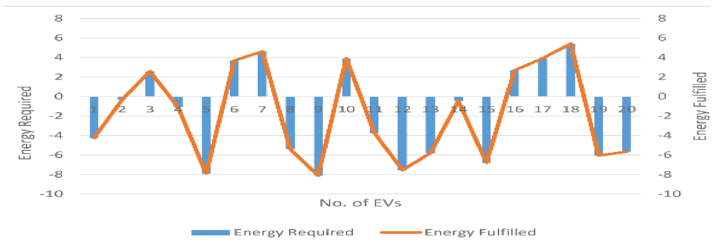


Fig . 3a. Energy Requirement Fulfillment of HBC set of vehicles

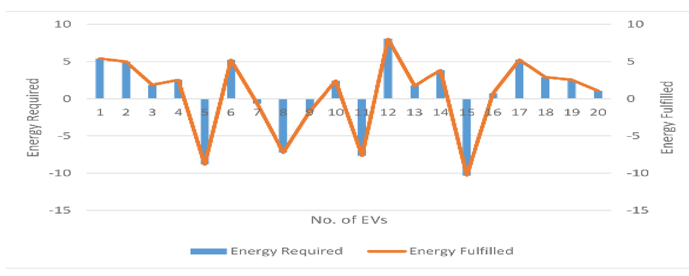
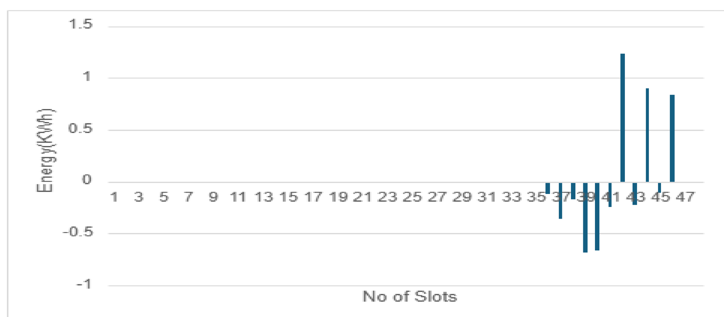


Fig . 3b. Energy Requirement Fulfillment of LBC set of vehicles

FOR MONSOON:



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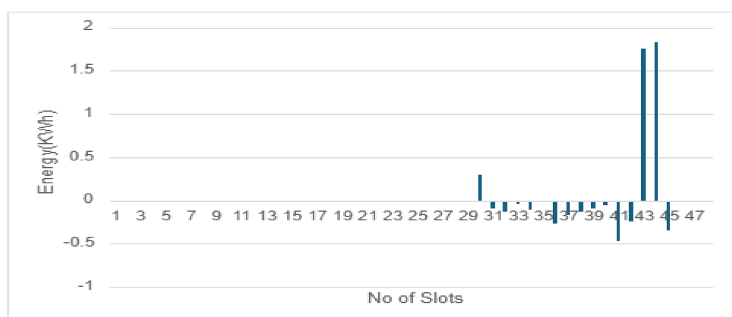
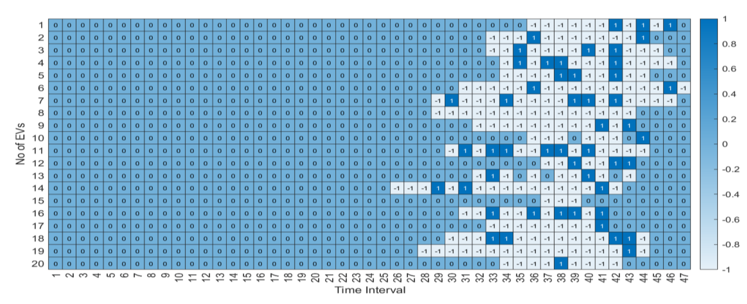


Fig. 1b. Energy Exchange of LBC set of vehicles for 24 hrs.



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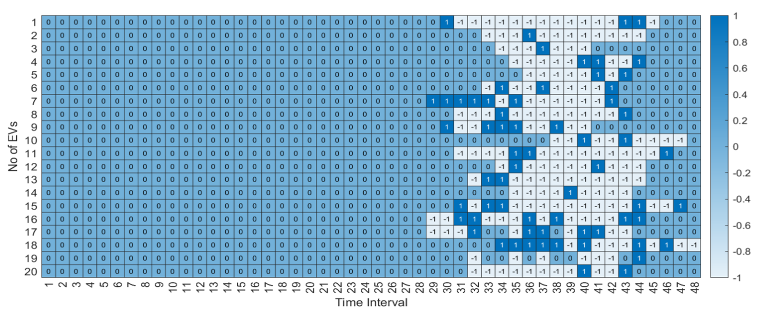

Fig. 2b. Charging Strategy for LBC set of vehicles considering G2V + V2G

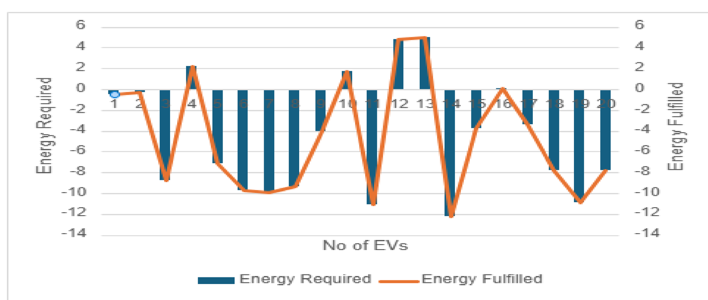

Fig. 3a. Energy Requirement Fulfillment of HBC set of vehicles

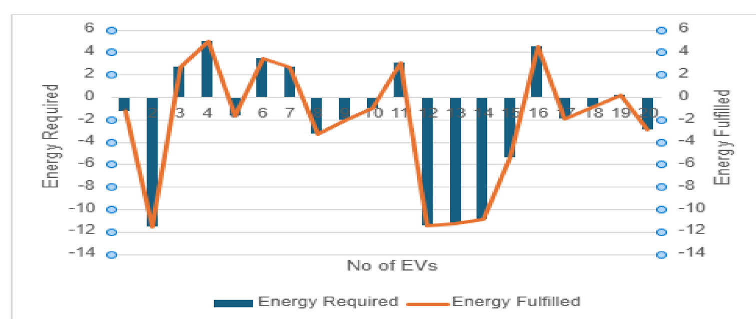

Fig. 3b. Energy Requirement Fulfillment of LBC set of vehicles

FOR WINTER:

Fig. 1a. Energy Exchange of HBC set of vehicles for 24 hrs.

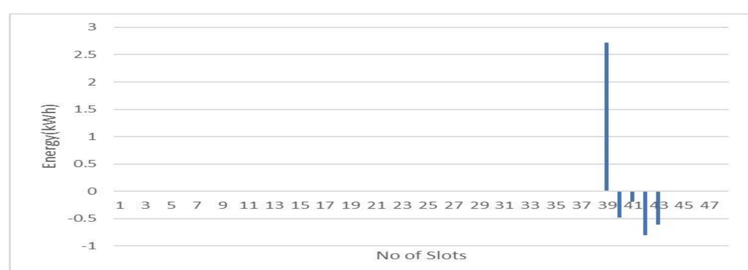

Fig. 1b. Energy Exchange of LBC set of vehicles for 24 hrs

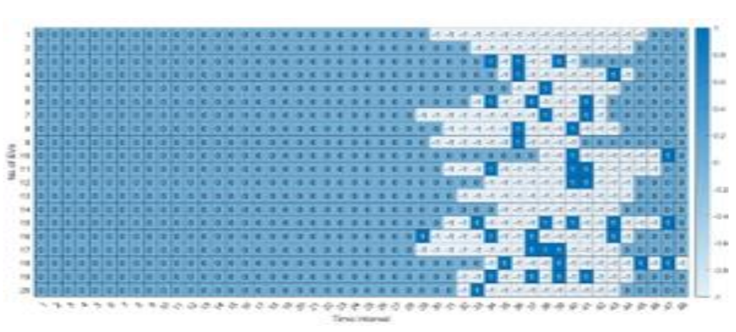

Fig. 2a. Charging Strategy for HBC set of vehicles considering G2V + V2G

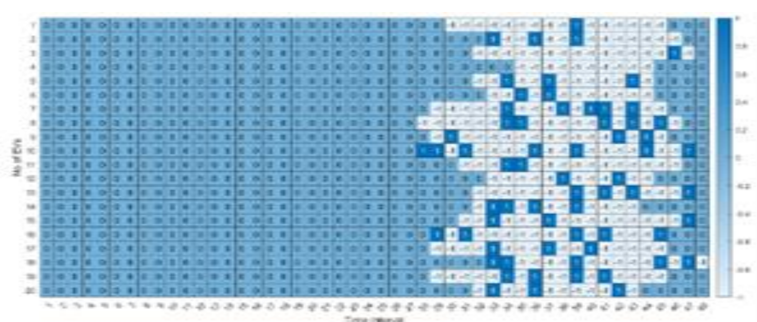

Fig. 2b. Charging Strategy for LBC set of vehicles considering G2V + V2G

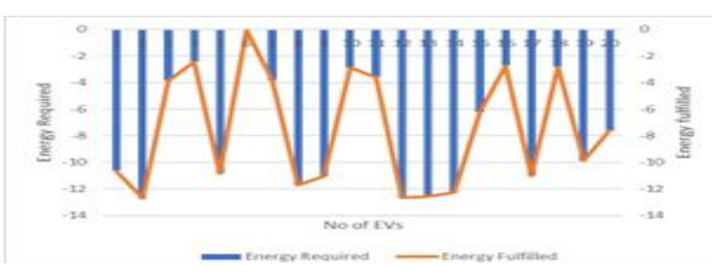

Fig. 3a. Energy Requirement Fulfillment of HBC set of vehicles

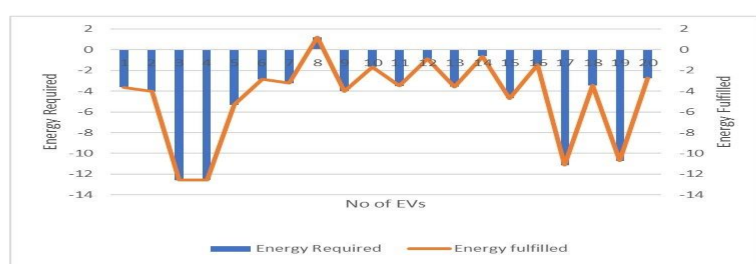

Fig .3b. Energy Requirement Fulfillment of LBC set of vehicles

REFERENCE

[1] EV Driving Across Seasons: SOC Strategies for Higher Battery Life Expectancy –Kashif Raza, Ijaz Haider Naqvi, Naveed UL Hassan.

[2]Data-driven analysis of battery electric vehicle energy consumption under real-world temperature conditions-Dongxu Yang, Hai Liu, Menghan Li, Hang Xu.