International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** III **Month of publication:** March 2019

DOI: http://doi.org/10.22214/ijraset.2019.3308

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue III, Mar 2019- Available at www.ijraset.com

Smart Scheduling of distinct PHEV Integrated in a Distribution System using Optimization Approach

Akshaya Preethi A[1], Balachander G[2] , Naveen S[3] , Thamarai Selvan N[4]
[1, 2, 3, 4]*Electrical and Electronics Department, INFO Institute of Engineering*

Abstract: Due to the increasing fuel prices of the fossil fuels, the global warming and green house gas effect has become the main threats in recent years. In order to reduce the increasing fuel prices , it is clear that Plug-in Hybrid Electric Vehicle (PHEV) has increasing electric grid reliability and improving battery health and life and it also has an environmental friendly solution to global researches. When compared to others PHEV has become an alternative solution to tackle the increase in peak load and power loss issues is done using the smart scheduling strategy. The aim of this paper is to minimize the total operating cost of the system and its performance is tested with IEEE 69 bus distribution system. In order to examine this work closer to real time operation, different types of PHEV's with different All Electric Ranges (AER) and battery capacities is analysed. Finally, the tested results are compared with Binary Particle Swarm Optimization (BPSO) algorithm it is tested using MATLAB Software.
Keywords: Plug-in Hybrid Electric Vehicles; Economic scheduling; Binary Particle Swarm Optimization (BPSO); All Electric Range (AER).

I. INTRODUCTION

Increasing fuel prices, diminishing fossil fuel reserves, rising greenhouse gas emissions and political unrest have made plug-in (hybrid) vehicles an attractive alternative to traditional internal combustion engine vehicles (ICEV). The growth of PHEVs as a clean, safe and economical transportation option to ICEVs can be promoted by extending driving range, improving battery health and life, increasing electric grid reliability and promoting acceptance of PHEVs by the consumer. The degree of penetration of PHEVs as a transportation option depends on a variety of factors, including charging technology, communication security, Advanced Metering Infrastructure (AMI), incentives to customers, electricity pricing structures and standardization.The wide-spread adoption of electric vehicles will have many multi-faceted socio-economic impacts. Among these increased system load, leading to stressed distribution systems and insufficient generation, power quality and reliability problems, degrading battery health, scheduling of vehicles as a potential power source in an ancillary market, costs incurred versus revenues earned by end user in offering such services, along-with the dependence on variable consumer behaviour have been considered as hurdles to PHEV implementation.

PHEVs are equipped with high capacity of energy storage system (ESS), they can acquire energy from the bulk power system via charging stations.

The increasing number of PHEVs may lead to the diffusion of the PHEV charging stations in several locations.The above formulation assumes that each charge station is equipped with large energy storage (battery) to serve as an energy exchange point.[1,2] Insufficient battery state of charge has been cited as the primary consumer insecurity regarding PHEV. As we have the desire to have a fully-charged battery at the beginning of the daily commute.

This consumer desire for daily full charge must be balanced against the desire on the part of the utility to shape its load curve and avoid a load spike due to concurrent vehicle charging. It is well-accepted that coordinated vehicle charging can be used to minimize the adverse effects of PHEVs on the electrical distribution grid .

Coordination can be either centralized or decentralized. A centralized strategy is one in which a central operator dictates precisely when every individual PHEV will charge, but may not be attractive to consumers who prefer to have complete authority over their transportation availability and/or electricity usage.

However, other objectives, such as system loss reduction, greenhouse emission reduction, battery lifetime extension, etc., can also be optimization factors. As a result of PHEV has a solution to reduce Carbon-di-Oxide emissions in transportation [3]. A centralized control strategy will require a central repository that collects parameter information from all vehicles to provide an optimal charging profile. Specifically, we propose an optimal approach to PHEV charging that [4] minimizes the cost to the customer of PHEV.

II. PROBLEM FORMULATION

A. Distribution Load Flow

Distribution system plays a significant position in the power system, since it is the main point of link between bulk power and the consumer. The load flow is run to explore different arrangements in order to maintain the required voltage profile and to minimize system losses. The main objective of load flow studies is to determine the bus voltage magnitude with its phase angle, real and reactive power flow in different lines and the transmission power losses. The IEEE 69 bus system is shown in the Fig.1. The Distribution load flow is performed using Backward and forward sweep Algorithm. The MATLAB Software tool is used for distribution network load flow calculation in order to find the optimal location for placing the charging station.

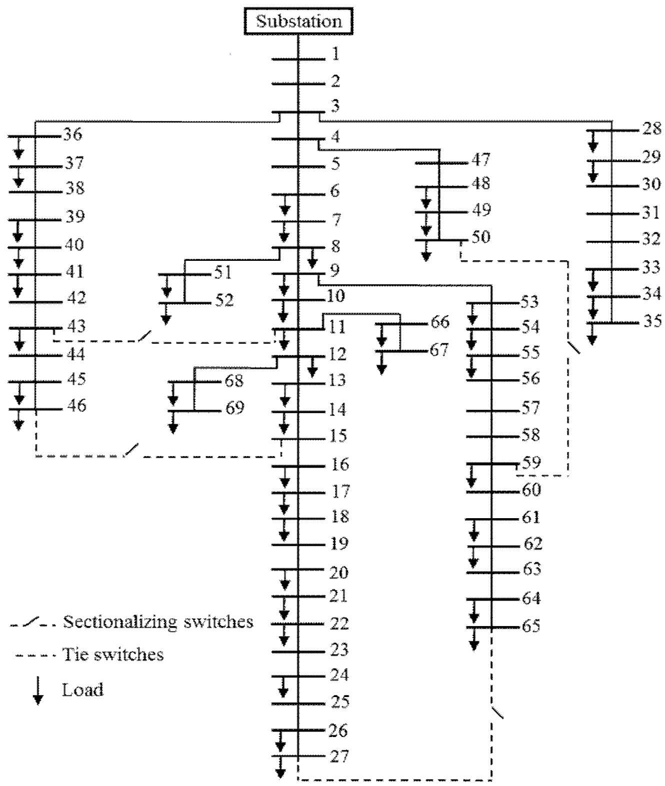


Fig 1: Single line diagram of IEEE-69 bus system

B. Information of PHEV

A PHEV is a hybrid electric vehicle those batteries can be recharged by plugging it to an external source. The information about PHEV like initial travel distance before entering the charging station, Subsequent Travel Distance (STD), in-time and out-time of the vehicles are required in order to determine the effective scheduling scheme based on the peak and off-peak hours.

C. Initial And Departure Time Of SOC of PHEVs

SOC is expressed as the amount of energy stored in a battery. The estimation of the SOC not only allows the application to make control over energy saving strategies but also prevent a battery over discharge and improving the battery life. Thus the calculation of the arrival and departure time of SOC of PHEV is given by,

$(SOC_a) = 1- (d/d_R)$

$(SOC_d) = (STD/d_R) + 0.2$

D. All Electric Ranges (AER):

All-electric range (AER) is the driving range of a vehicle using only power from its electric battery pack to traverse a given driving cycle. In the case of a battery electric vehicle, it means the total range per charge. For a PHEV, it means the range of the vehicle in charge-depleting mode. PHEVs can travel considerably further in charge-sustaining mode which uses both on-board fuel and the battery pack and the % of vehicle used for analysis is given in Table-1.

TABLE I
Aer Ranges With Their Battery Capacities

AER Range	Battery Capacity	Percentage of vehicles used
AER – 14	11	20%
AER – 18	14	30%
AER – 40	25	50%

III. PROBLEM OVERVIEW

A. Charging And Discharging Cost

The charging of the vehicles is carried out in off peak hours and then the discharging of vehicles is carried out in peak hours. In order to reduce our charging price, we can charge our vehicle in off peak hours and discharging at peak hours so that the charging cost is effective. By these types of charging and discharging action we can reduce our power demands.

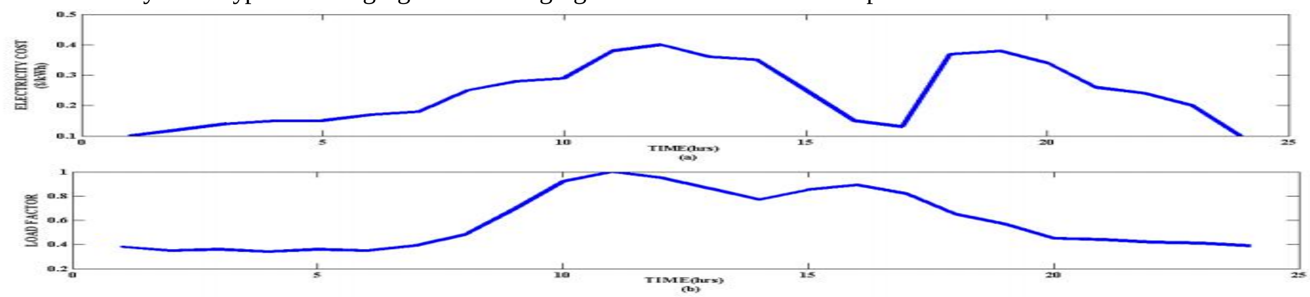


Chart 1: (a) Electricity (b) Load factor

B. Schematic Diagram

Here we find an optimal location for scheduling the PHEV, which is parked in the charging station for either charging or discharging based on its energy requirement. With dedicated charging points, both Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) functionalities are provided in the charging stations. All the cars parked in the charging station are assumed to be contracted to a charging coordinator. The PHEV's arrival time, departure time, Subsequent travel distance (STD), battery capacity, AER is given to the charging station coordinator by the vehicle owner. The energy required for the PHEV is calculated by the means of data collected from the PHEV owners. And then, the optimal scheduling is performed by using BPSO Algorithm. The performance of the BPSO algorithm is tested using the IEEE 69 bus system. Finally, the smart scheduling of PHEV is done and the distribution system stability is maintained within their acceptable limits and the schematic framework of the PHEV scheduling is shown in Fig-3

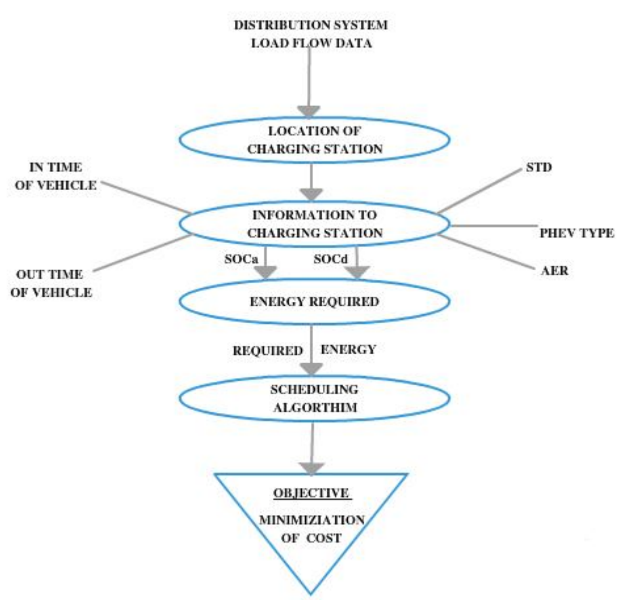


Fig-2: Schematic framework of PHEV Scheduling

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue III, Mar 2019- Available at www.ijraset.com

IV. MATHEMATICAL MODEL

At peak hours the controlled discharging as well as the advantage of off-peak hours charging benefits of PHEV owners and the grid operators in decreasing the total operating cost of the system.

A. Objective

The main objective of the work is to minimize the total operational cost of the system which comprises of two parts:

1) Charging and Discharging Cost
2) Battery Depreciation Cost

$Minimize(Cost)$

$$Cost = Cost_{CD} + Cost_{Bdep} \quad (1)$$

$$Cost_{CD} = \sum_{t=1}^{T}\left(\sum_{k=1}^{N}(CH_k - DCH_k).r_{PHEV,k}\right).RC(t) \quad (2)$$

$$Cost_{Bdep} = \sum_{t=1}^{T}\left(c_{b,k}E_{b,k} + c_L\right).E_{dis,k}/(L_c E_{b,k} DOD) \quad (3)$$

where,

CH_k = Total charging power of PHEVs

DCH_k = Total discharging power of PHEVs

$r_{PHEV,k}$ = Rate at which k^{th} PHEV is charged or discharged

RC(t) = Real time cost at a given time slot t.

$E_{b,k}$ = Battery capacity of k^{th} PHEV.

$E_{dis,k}$ = Total energy discharged by k^{th} PHEV

$c_{b,k}$ = Cost of battery per kWh for k^{th} PHEV.

c_L = Labor cost for battery replacement.

DOD = Depth of discharge of the battery.

L_c = Battery lifecycle at a particular DOD.

B. Constraints

In order to avoid any uncertainties in the system there are certain parameters which must be maintained in their permissible limits as follows,

1) PHEVs energy requirement constraint.

$$\sum_{t=t_{in,k}}^{t_{out,k}} s_k^t . r_{PHEV,k} = E_{req,k} \quad (4)$$

2) Rated charging power limit.

$$0 \leq r_{PHEV,k} \leq P_{rated} \quad (5)$$

3) PHEVs battery SOC limit.

$$20\% \leq SOC \leq 100\% \quad (6)$$

C. State of Charge Evaluation

A Set of 50 vehicles with predefined arrival and departure time is considered. The initial SOC (SOC_a) and the desired departure time SOC (SOC_d) is calculated based on the first trip distance (d) and the Subsequent Travel Distance (STD) of the PHEVs using (2.1) & (2.2). The required SOC (SOC_r) of PHEVs entering the charging station is determined by the charging coordinator using the PHEVs (SOC_d)

1) (SOC_r) positive if ($SOC_d > SOC_a$)
2) (SOC_r) zero if ($SOC_d = SOC_a$)
3) (SOC_r) negative if ($SOC_d < SOC_a$)

The equation to be used for calculating required SOC for PHEVs is given below

$$SOC_r = \begin{cases} 1 - SOC_a, & (SOC_d > 1) \\ (SOC_d - SOC_a), & SOC_a < SOC_d < 1 \\ 0, & SOC_d = SOC_a \\ -(SOC_a - SOC_d), & 0.2 < SOC_d < 1 \end{cases} \quad (7)$$

D. Energy requirement of PHEVs

Finally, the energy required for each vehicle to travel its next trip is calculated using the given formula as,

$E_{req} = (SOC_r.C)$

where,

E_{req} = Energy required for each PHEV

C = Battery capacity of a PHEV

Based on the energy required calculated for each vehicle, if it is positive then charging need to be carried out. If the energy required is negative discharging is performed. If it is zero, then the available energy is sufficient to travel the next trip.

V. METHODOLOGY

A. Smart Scheduling Strategy Using BPSO Algorithm

PSO algorithm was developed initially for problems that are continuous in nature. Since, most of the real time problems are discrete in nature and finally discrete or binary version of PSO is also proposed. The BPSO start with initialization of particles and then successively updating velocity position, local best and global best solution at each iteration.[13]

1) Algorithm: Binary PSO (BPSO)
2) Require: No. of Particles, MaxIter,Input File
a) Read Input File
b) Initialize Particles
c) while (iter ≤ MaxIter) do
d) for all (Particles i) do
e) Update Velocity Vi of Particle i
f) Update Position Xi of Particle i
g) Validate Xi for duplicate codes
h) if (currentSolutioni < pBesti) then
i) pBesti = currentSolutioni
j) end if
k) end for
l) gBestiter = min ∀i (pBesti, gBestiter−1)
m) iter++
n) end while

VI. RESULTS AND DISCUSSIONS

A. Energy Required

To test the robustness of the smart scheduling strategy, more number of vehicles with different type of PHEVs to be scheduled is analyzed. It is not feasible to have a same type of vehicles so in this paper a set of 50 vehicles are considered to perform the smart scheduling. It is assumed that three types of PHEVs are considered for this work: PHEV-14, PHEV-18 and PHEV-40 type.

B. Energy required for Scheduling

The energy required for the PHEVs in order to travel further is calculated using (4). The required energy for the vehicle either for charging or discharging is shown in Chart-2

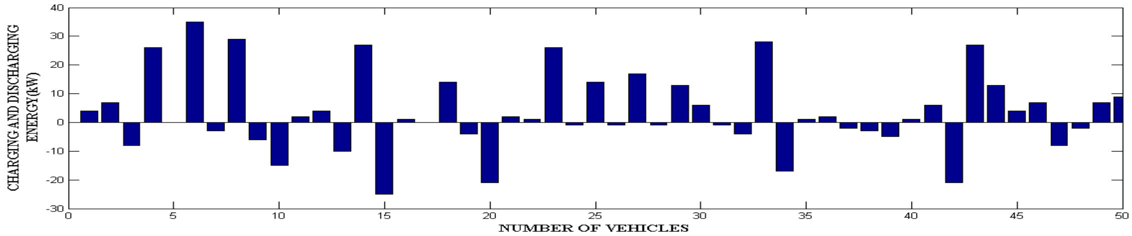


Chart 2: Energy requirement chart

C. Optimal location for PHEV charging Station

After adding additional PHEV load to each bus of the system, the optimal location for placing the charging station is chosen as bus 28 based on the minimum real power loss obtained, compared to other bus and is shown in Table-2.

TABLE-2
Optimal Charging Station Location

PARAMETER	BPSO ALGORITHM	
Bus location	28	65
Real power loss (KW)	224.9656	233.6573

D. System Load Data After PHEV Integration

Once the optimal location is chosen, the system load to be added in the actual system for 24 hours at the particular bus is been compared with uncontrolled scheduling and BPSO algorithm is listed in Table-3 where the load added during peak hours i.e., 11 a.m. and 12 p.m. using BPSO algorithm is considerable to the base case load when compared to uncontrolled scheduling scheme.

TABLE-4
Load Variation At Optimal Charging Station Location

No of hours	Base load (KW)	System voltage after integration of PHEV load (p.u)	
		Uncontrolled scheduling	BPSO algorithm
1	9.88	9.88	9.88
2	9.1	9.1	9.1
3	9.36	9.36	9.36
4	8.84	8.84	8.84
5	9.36	9.36	9.36
6	9.1	13.1	9.1
7	14.14	20.14	10.14
8	32.48	18.48	12.48
9	31.94	28.94	17.94
10	43.92	50.92	23.92
11	77	34	26
12	60.7	41.7	24.7
13	13.36	19.36	22.36
14	36.02	40.02	20.02
15	23.1	27.1	22.1
16	4.14	46.14	23.14
17	16.32	31.32	21.32
18	30.9	22.9	16.9
19	26.82	32.82	14.82
20	15.7	3.7	11.7
21	20.44	24.44	11.44
22	17.92	12.92	10.92
23	10.66	16.66	10.66
24	10.14	10.14	10.14

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue III, Mar 2019- Available at www.ijraset.com

E. Total Operational cost of the System

The convergence graph of the Binary PSO algorithm considered to perform the optimal scheduling of the PHEV per day is shown in Chart-3.

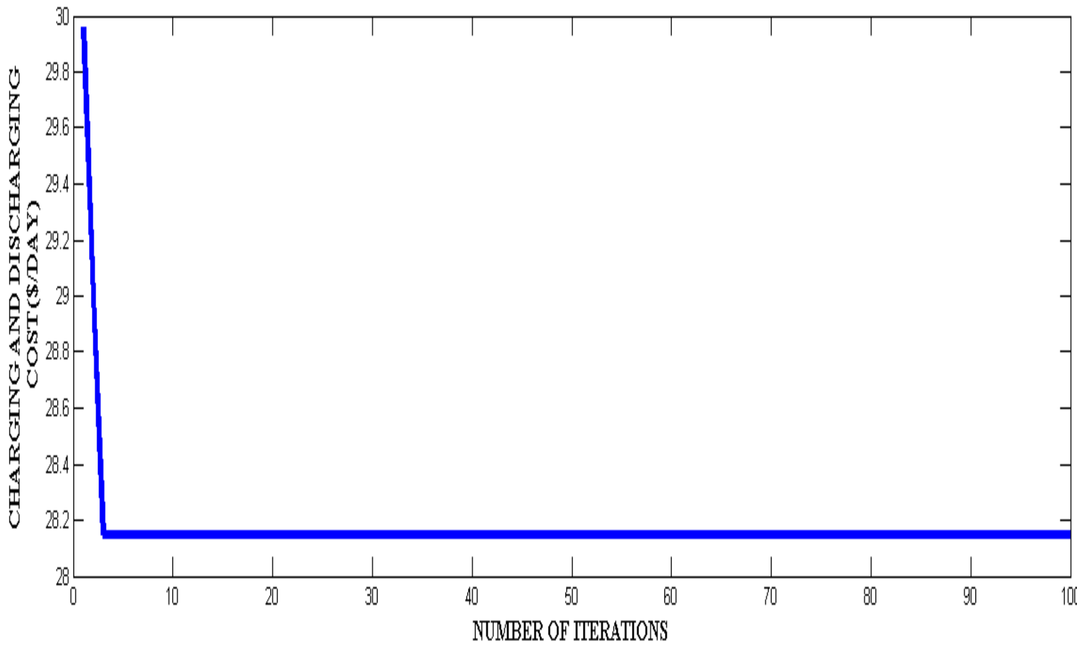


Chart-3: Convergence plot using BPSO algorithm

By implementing Smart Scheduling strategy using BPSO algorithm the charging and the discharging cost is calculated. By using the value of the depth of the discharge the battery depreciation cost is calculated. as shown in Table-4.

TABLE IV
Total Operating Cost

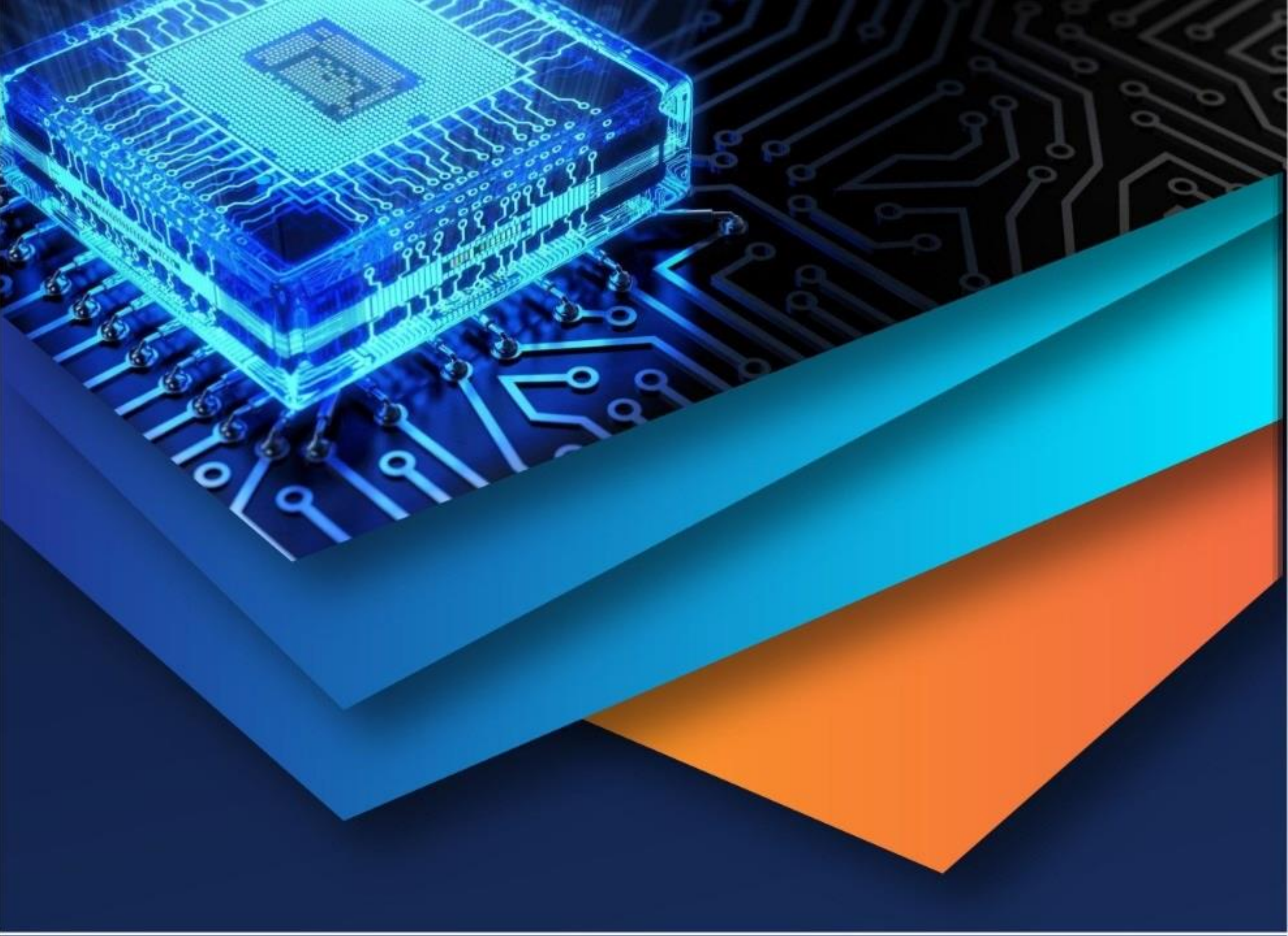
PARAMETER	UNCONTROLLED SCHEDULING	BPSO ALGORITHM
Cost($/day)	63.45	28.15
Battery Degradation Cost($/day)	7.8979	7.8979
Total Operating cost($/day)	71.3479	36.0479

VII. CONCLUSION

In this paper, the optimal scheduling of the PHEV is performed in IEEE 69 Bus using BPSO Algorithm. The grid operators and vehicle owners are benefited by finding an optimal location for the charging station and also by performing coordinated scheduling of PHEVs. The test results were analysed by varying the vehicles AER and battery capacities.This provides up to 50.52% of lesser cost than the uncontrolled charging. It is evident from the result that the smart scheduling strategy using BPSO algorithm is better when compared to uncontrolled scheduling strategy, thus the objective of attaining minimum total operating cost of the system which comprises of charging and discharging cost as well as battery degradation cost is achieved without violating any constraints.

REFERENCES

[1] Zhaohao Ding, Ying Lu, Lizi Zhang,Wei-Jen Lee, and Dayu Chen "A Stochastic Resource Planning Scheme for PHEV Charging Station Considering Energy Portfolio Optimization and Price-responsive Demand ",IEEE Transactions on Industry Application,vol.54,pp.5590-5598,2018.
[2] Abdurrahman Arikan , Ruofan Jin, "Optimal Centralized Renewable Energy Transfer Scheduling for Electrical Vehicles "IEEE International conference on smart grid communication,2015.[https://doi.org/10.1109/SmartGridComm.2015.7436308]
[3] Mohammad javad Mirzaei, Ahad Kazemi, Omid homaee,"Real World based approach for optimal management of electric vehicles in an intelligent parking lot considering simultaneous satisfaction of vehicle owner and parking operator", Energy (Volume 65 pages 572–579, 2014; doi:10.1016/j.energy.2013.11.045).
[4] Feiran Huang Wei-Jen Lee, "Design Optimization of PHEV Charging Station",IEE Industrial and commercial power system conference,2012.[https://doi.org/10.1109/ICPS.2012.6229606]
[5] Hong.B, "plug-in hybrid electrical vechicles (PHEV)," IEEE Emerg.technol.portal,2012.
[6] Dr.S.Charles Raja, S.Suganya, J.Jeslin Drusila Nesamalar and A.Akshaya Preethi* "Economic scheduling of Plug-In Hybrid Electric Vehicle considering various travel patterns",National power engineeringconference,2018.[https://doi.org/10.1109/NPEC.2018.8476752]
[7] Arvind Kumar , Vikas Bhalla , Praveen Kumar "Unit Commitment in a Smart Grid with Plug-in Hybrid Electric Vehicles- A Cost-Emission Optimization", IEEE Transpontation Electrification conference, 2017. [https://doi.org/10.1109/ITEC-India.2017.8333714]
[8] Aiman H,El-Maleh,Ahmad T.Sheikh,Sadiq M. Sait,"Binary Particle Swarm optimization based state assignment for area minimization of sequential circuits" ,Applied soft computing ,vol.13,pp.4832-4840,2013.
[9] Livani R. Jalilzadeh Hamidi "Myopic real-time decentralized charging management of Plug-in Hybrid Electric Vehicles",Electrical power system Reasearch,vol.143,pp.522-532,2017.
[10] Imran Rahman , Pandian M.Vasant , Balbir Singh MahinderSingh , M. Abdullah-Al-Wadud "Review of recent trends in optimization techniques for Plug-in Hybrid, And Electric Vehicle charging infrastructures",Renewable and suitainable energy Review,vol.58,pp.1039-1047,2016
[11] Nima Ghiasnezhad Omran a, Shaahin Filizadeh, "A semi-cooperative decentralized scheduling scheme for plug-in electric vehicle charging demand",International Journal of Electrical power and energy system,vol.88,pp.119-132,2017.
[12] Qiuminv Dong, Dusit Niyato, "The PHEV Charging Scheduling and Power Supply Optimization for Charging Stations,"IEE Transaction on vehicular Technology,vol.65,pp.566-580,2016.
[13] Yoshito Nishita and Masafumi Iwata "Control Charge-Discharge Using EV and PHEV Batteries for Power Demand Reduction",IEE International Telecommunication Enwergy conference,2015.[https://doi.org/10.1109/INTLEC.2015.7572445]
[14] Rahul Mehta, Dipti Srinivasan, Asiwin M "Smart Charging Strategies for optimal integration of plug-in Electric vehicle within Existing Distribution system infrastructure", IEE Transaction on smart grid,vol.9,pp.299-312,2018.
[15] Maigha, Mariesa L.Crow," Economic scheduling of Residential Plug-in Hybrid Electric Vechicle Charging, Energies , vol.7, pp.1876-1898,2014.



10.22214/IJRASET

45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY