INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
*(Volume 7, Issue 6 - V7I6-1262)*
Available online at: https://www.ijariit.com

# Energy management in smart grid using hybrid combination of bat and particle swarm optimization algorithm

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## ABSTRACT

***In order to implement the increasing rate of demand in the residential sector and also that to facilitate the overall integration of the renewable resources and that the plug-in of the electrical set of vehicles within the future if the smarter grids. This particular set of papers proposes a proper set of framework for the home energy management system or the HEMS and that of the optimisations of the algorithms which is based upon the hybrid combination of BAT and PSO algorithm. The simulation is performed in MATLAB and various performance metrics are calculated for it. The result shows that the proposed method reduces 76.04% and 55.31% cost factor as compared to the actual load for 3 and 5 devices. Further, the proposed method reduces 59.81% and 38.59% cost factor as compared to Sisodiya et al. [12].***

***Keywords***: *Smart Grid, Particle Swarm Optimisation, Energy Management, Bat Algorithm.*

## 1. INTRODUCTION

At present, electrical power is seen to play a significant as well as that of a detrimental role within human life and it also supports some of the vital set of utilities and that of the infrastructures [1,2]. One of the significant sets of electrical generation is needed globally still it comes from fossil fuels. Moreover, fossil fuels keep on supplying all that have become scared. Moreover, fossil fuels are seen to be burning with the help of the production process of electricity and that all of them release large amounts of carbon emissions that cause climate change and global warming. This creates an awareness which has encouraged interest within the suitable sources of energy for the development which uses clean sources of energy as well as that of renewable sources of energy [3]. For example, all of the renewable energy sources or the RES involves wind, solar, hydro and that for the biomass. All of these alternatives keep on improving the supply of power, increasing the rate of the ongoing production of energy, decreasing the rate of dependency on fossil fuels and that of the reduction of carbon emissions. At present, the power grid of the convention has been changing towards a much smarter set of grid, that is a powered set of the grid which is being combined with all of the technologies of communication and event information [2-5]. A much wider set of acceptance definitions of the smarter set of grid technologies includes an intelligent segment of control of the intermittent of the production which is a two-way connectivity in between the suppliers and that of the users and also the usage of the advanced set of ICT [5]. Along with this it also allows to have a dynamic set of optimisation and that of the continuous set of the coordination of the operations of the grid and that of the energy resources, A much smarter set of the grid technology is being seen as per the significance which enables to have a transformation with more than a sustainable set of electric networks since the fat it has started to boost all of the adoption of the RES into that of the powered set of grids. Depending upon the side of the demand, Smarter set of buildings and that of the smarter homes which are seen to be critical for the smart grids and its functionalities and that of the performance which needs to be boosted for controlling of the optimisation of the infrastructures and that of the resources which are also increasing with the energy efficiency [2,3]. Apart from this they also keep on integrating the digitised set of sensing and that of the communication devices with all of the grid and utilities. Along with this there are certain other growing attention within smart energy management systems or the EMS for the smarter set of homes or that of the home energy management systems, HEMS, BEMS or that of the building energy management systems and that of the smarter set of grids [3,6-8]. Methods of the optimisation which is based upon which is common which is being used within the energy management systems. Along with this with the developments within biologically inspired computing or the bio-inspired computing and the artificial intelligence methodology have been shown through priming of success onto the issues of optimization [9-11].

One of the main sets of constriction of this particular set of contributions of the algorithms of the bio-inspired for the management of energy within smart grid. According to Sisodiya et al. [12], a proper set designed upon the management of energy methods is being used through the algorithm of the PSO. The algorithm of the PSO is seen to be facing two sets of challenges, for example the local set of optima and that of the lower set of convergence rate in order to find out a proper set of the optimal solutions. Within our work we need to overcome all of these issues through hybridization of the algorithm of the PSO and that of the BAT.

An absolute set of errors is being taken as per the objective set of functionality from within the proposed method. The simulation is being performed completely onto the same set of data as taken through Sisodiya et al. [12]. Moreover, various sets of performances and its metrics for example cost, load and that of the time of execution needs to be calculated for the proposed set of methods. After this the results which show the fact that the proposed method is much more superior to that of the existing set of designed methodologies as per Sisodiya et al. [12].

The rest of the paper is being set to follow as follows. In Section 2 which shows the related set of work which is being done within this particular set of fields of energy management. Apart from this in the Section 3 which completely defines preliminaries which is being required for designing of the proposed set of methodologies. Section 4 completely illustrates the proposed set of methods followed by Section 5 which shows simulation and evaluation of the proposed set of methods. The last section which section 6 shows conclusion and that of the future scope.

## 2. RELATED WORK

In this section, the existing methods are explained that are designed for the management of the smarter grid.

**Sisodiya et al. [12],** HEM or the Home Energy Management is known to be one of the important sets for utilisation as well as that of the environment. Within this particular set of paper which presents an important set of incorporation of the ESSs or the energy storage systems as per the electric vehicle or the EV and that fo the UPS or the uninterrupted power supply with the proper set of utilisation with the help of the DR or the demand response for the reduction of the electricity bill of a home. Ventilation, heating and that of the air condition or the HVAC, EWH or the electric water heater and that of the electric water pump or the EWP are being taken as per the lords of the house. The ESSs keeps on operating as per the loads as well as that of the sources of energy. All of these are known to be the home devices that are being scheduled with the usage of PSO or the particle swarm optimization algorithm within the environment of MATLAB which includes the curtailments. The proposed set of the schemes are being resulted within a significant set of bills and its reduction at the time of maintaining the requirements of the users.

**Kirtanpal Singh and Puneet Jain [13],** a much smarter set of the grid is being advanced to the powdered form of grid and that of the electricity which is in demand and it is being managed and it is being controlled through it. An electrical set of demand is increasing at the peak hours of the day. Therefore, in order to fulfill the demand of the electricity for either to generate the extra amount of electricity within the peak hours which increases the cost or even reduces the overall load within the peak hours. At the time of the load peak hours are being reduced through the adoption of a demand-side management technique. All of these techniques are being reduced through the generation of costs and that of the performances of the smarter set of the grid which needs to be improved. Along with this the paper also provides a new or the latest set of an approach which is known as the hybrid of BAT, and that fo the optimisation of the Firefly and it is being used for controlling of the overall switches on time of the devices so as to make sure that the overall laid could be easily minimized. An experimental set of results are being performed for different devices (3 and 5). The results of the simulation shows that the proposed set of algorithms keeps on reducing the overall cost which is being compared to that of the original amount of costs. At last, it can be stated that we need to compare the performance of the proposed set of algorithm to that of the existing set of the Particle Swarm Optimisation of the PSO and is being found that the 47.02% and that fo the 36.48% of the cost is being reduced for every 3 and 5 devices respectively.

**Razky et al. [14],** in recent there has been a smart demanding side for the management or the DSM which is much more important tool which permits all of the customers to take up the right set of decisions for their consumption of energy and that also it helps in the utilisation of the energies for decreasing of the overall load demand and that to reshape the curve of load. Along with this the paper also proposes an optimisation of the techniques of the DSM which is completely based upon the smart metering usage of the different set of techniques for examples the shifting of load and that of the peak clipping for the minimisation of domestic set of power consumption espaillat at the time of load peaks. A completely new set of optimisation or the BAT algorithm is being applied in order to propose the system and that of comparing results with other site of the techniques of optimisation or the Genetic Algorithm and Interior point Algorithm for optimisation which is having a minimum amount of consumption at the time of peak hours in accordance to the laid type. A controlled form of algorithm is to be proposed for the system which achieves the shifting of load and that of the clipping of load in accordance to the optimisation of results.

**Javaid et al. [15],** HEM or the Home energy management systems are being widely used in order to cope up with the new set of increasing demand of the energy. All of them help to completely reduce the pollutants of the carbon content which is being generated through excessive amounts of burning of the natural set of resources and that of the fuel ahch is being required for the generation of energy. Along with this budget also needs to be saved for installation of the new set of the powered plants. The price is based upon the automotive ser of the demanding response or the DR techniques which needs to be incorporated within these systems for shifting of the appliances from a higher set of pricing hours to that of the lower set of pricing hours for reducing the bills of electricity and that of the peak to that of the average amount of ratio or the PAR. Within this paper, load of electricity of the home is being categorised into three different types that is base laid, shiftable non-interrupted load and that fio the shift-able interruptible. Within the literature there are many metaheuristic sets of optimisation techniques which have been implanted for the scheduling up of appliances. Within thai work in order to optimise usage of energies genetic algorithm or the GA and that of the bat algorithm or the

BA is being implemented along with time of the usage or that of the TOU and the pricing of the scheme for scheduling of the applications for reducing of the bills of the electricity, peak to that of the average set of ration for the appliance delay time. A completely new set of techniue or the BGA is being proposed. A hybrid of the BA and that of the GA and its outperforms of the BA and that of the GA in terms of the reduction of costs and that of the average amount of ration for a single set of home scenarios along with that of the multiple set of home scenarios. Time for operation internals or the OTIs for 15 minutes, 30 minutes and that of 1 hour that has been considered for checking all of their effects onto the reduction of costs, user comfort or the UC and that of the PAR.

**Pamir et al. [16],** within the smarter set of grids or the SG, the demand side management or that of the DSM is known to be a set or even group of the programs that allows consumers to keep on playing a much more vital set of role in transferring of all of their own set of load at the time of peak periods and that for minimizing their hourly based set of power consumptions and that of the total amount of monetary costs of the electricity which needs to be consumed and along with this it also helps for the electricity to be utilised for reducing of the higher rate of powered demand within time for higher energy demanding time slots. The consequent set of results within the reduction of the total amount of cost of the electricity, maximisation of the powered amount of grids and its sustainability and that of the reduction of the carbon dioxide emission that ultimately results in the free environment pollution. At present, maximum of the strategies of the DSM is available within the existing set of concentration of the literatures on to the households appliances scheduling in order to decrease the consumer delay timing and that of the peak time to that of the average set of ratio oir the PAR. Moreover, they might ignore the overall total amount of cost of the electricity and in this paper we went on to employ a strategy of load shifting for decreasing the total amount of electricity payment. In order to gain the above set of objects we need to propose a complete set of hybrid of the algorithm of the BA and that of the CSA or the Crow Search Algorithm, that is the BCSA or the bat-crow search algorithm and that all of the results must be compared within the existing set of CSA and BA. Along with thai the simulations were being conducted for a single set of home with around 15 appliances with the suage so the the CPP or the critical peak pricing scheme for the computations of the electricity bill of the consumers. All of the results are being shown which shows that the load is much more successful and must be shifted towards the lower range of process of the time slots with the usage of the proposed set of BCSA techniques that ultimately leads towards the 31.191% reduction to that of the total electricity payment.

## 3. PRELIMINARIES

Bat and Particle Swarm Optimization (PSO) algorithms are deployed for energy management in the proposed method. Therefore, an overview of these algorithms is given in this section.

### 3.1 Bat Algorithm

Bat algorithm is a modern method of providing good results as compared to many conventional and interrogative algorithms used to resolve the complicated and complex engineering issues [13]. It is utilized for the echo-location of micro-bats. Etiolation or echolocation is a sonar wave that is produced by micro-bats, which helps them in finding prey, and also, with the help of this, sometimes they are able to differentiate the barriers or danger caused on their path in darkness. The loud and high-frequency ultrasonic waves are produced by bats, and the reflecting back echo from the object in the surrounding is heard by them. The rules used by the bat algorithm are simple and listed below.

• To sense/ feel the prey, any obstacle or predator on the way, echolocation is used by bats.
• Position and velocity is used by bats to fly. The loudness and frequency f is used to approach the prey. The pulse emission frequency r is adjustable.
• When it approaches the prey, the loudness reduces, and the pulse increases.

### 3.2 Particle Swarm Optimization (PSO) Algorithm

Following are the basic equations for particle swarm optimization (PSO). In each iteration, the position of the particle is updated by its velocity as given in the equation below [12].

$$\begin{aligned} v_i(t+1) =& w \times v_i(t) + c_1 \times r_1 \times [p_{best_i} - x_i(t)] \\ &+ c_2 \times r_2 \times [(g_{best} - x_i(t)] \\ x_i(t+1) =& x_i(t) + v_i(t+1) \end{aligned}$$

where, p is the number of particles, t is the iterations number, r1,r2 are the random numbers between [0,1], c1,c2 are the acceleration constants, w is the inertial constant. There are considered 100 particles (p).

### 4. Proposed Method

The proposed method is designed to scheduling the electric load for energy management in the smart grid. The flowchart of the proposed method is shown in Figure 1.

Initially, load devices information is read. In our work, we have taken 3 and 5 devices that are under consideration. The devices are HVAC, Electric Water Heater, Electric Water Pump, Electric Vehicle, UPS-Inverter. After that, initialization of parameters is done for BAT and PSO algorithms. Next, energy management is done using the hybrid combination of BAT and PSO algorithm until termination criteria is not found. In the last, performance analysis of the proposed method is done using various parameters such as load, cost, and execution Time.

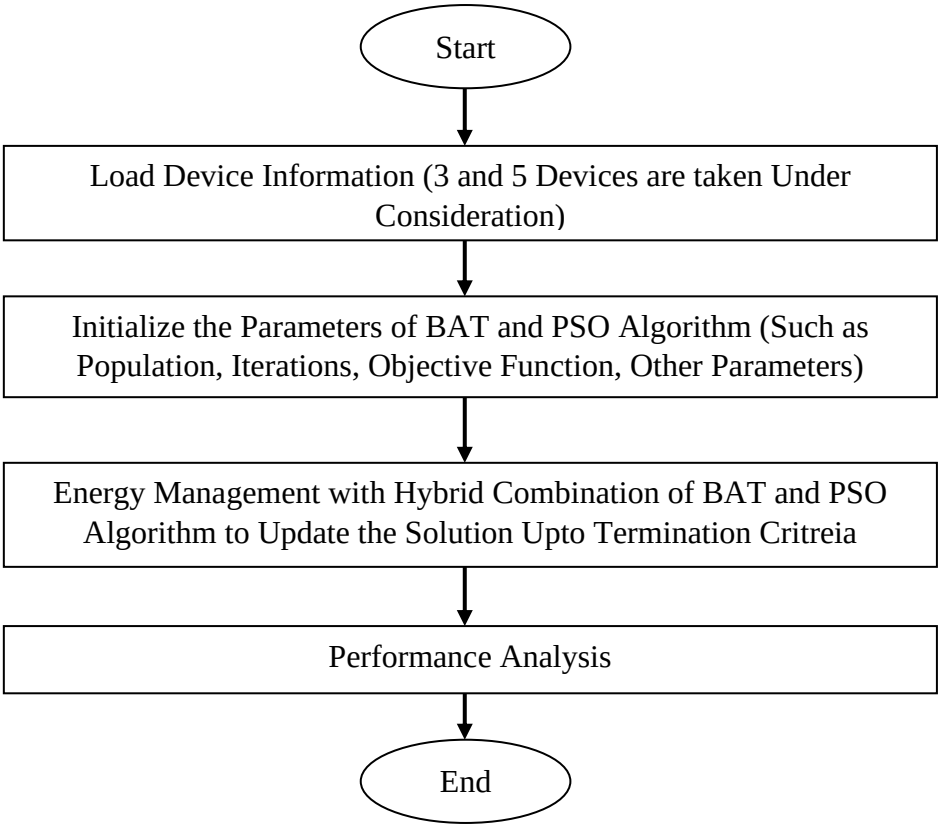



**Figure 1 Flowchart of the Proposed Method**

## 5. SIMULATION EVALUATION

In this section, the simulation evaluation is done for the proposed method to show its effectiveness over the existing method. MATLAB software is used for simulation purposes.

### 5.1 Simulation Setup

In this section, the simulation setup for the proposed method is shown in Table 1.

**Table 1 Simulation Setup for the Proposed Method**

| Parameters | Value |
|---|---|
| 3-Devices | HVAC, Electric Water Heater, Electric Water Pump |
| 5-Devices | HVAC, Electric Water Heater, Electric Water Pump, Electric Vehicle, UPS-Inverter |
| Objective Function | Absolute Error |
| Iterations | 100 |
| Loudness (A) | 0.5 |
| Pulse Rate (r) | 0.5 |
| Frequency Minimum (Qmin) | 0 |
| Frequency Maximum (Qmax) | 2 |
| Lower Bound (Lb) | 0 |
| Upper Bound (Ub) | 1 |
| C1 and C2 | 2 |
| w | 0.5 |
| Velocity | Rand(1,n) |

### 5.2 Performance Metrics

In this section, performance metrics are explained that are calculated for the proposed method.

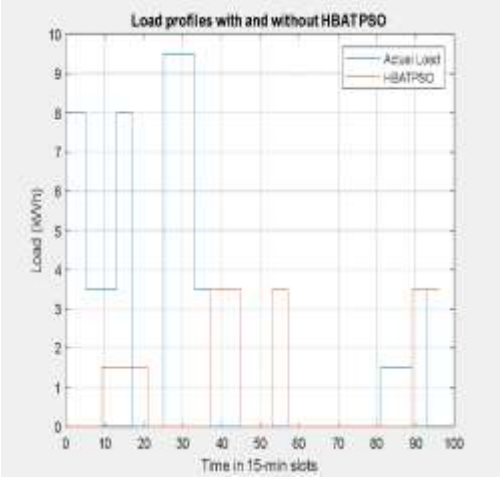
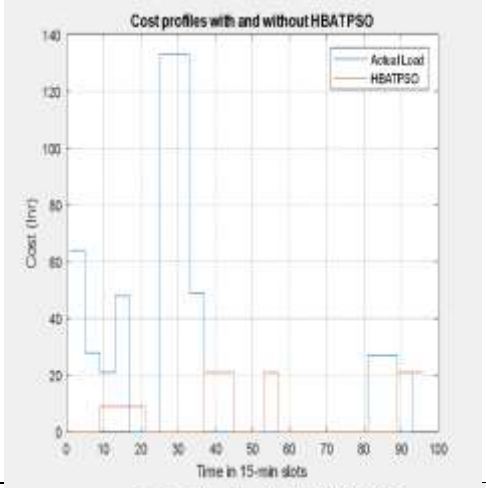
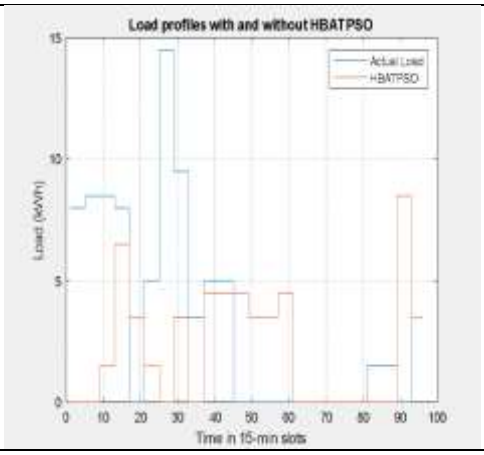
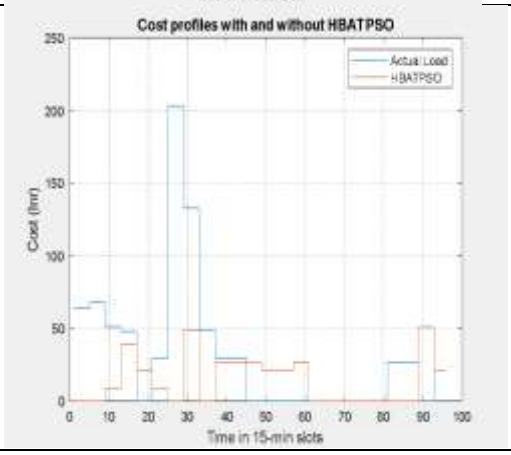
- Load: This metric calculates the total load consumption and is measured in kWh.
- Cost: This metric calculates the total cost of the load and is measured in rs.
- Execution Time: This metric measures the total time spent on the simulation of the proposed method.

### 5.3 Simulation Results

In this section, the simulation results of the proposed method are shown. In our work, 3 and 5 devices are taken under consideration. Table 2 shows the load and cost profile for the 3 and 5 devices. The results show that the proposed method reduces the load and cost profile for these devices as compared to the actual load and cost profile.

**Table 2 Load and Cost Profile For Different Devices (3 and 5)**

| Devices | Load Profile | Cost Profile |
|---|---|---|
| 3 |   |   |
| 5 |   |   |

Further, Table 3 shows the various performance metrics for the proposed method. The result shows that the proposed method reduces 57.7% load consumption and 76.04% cost factor for 3 devices. On the other hand, the proposed method reduces 34.76% load consumption and 55.31% cost factor for 5-devices.

**Table 3 Simulation Results for Different Devices**

| Devices | Load (KWh) | | Cost (Inr/KWh) | | Execution Time (in Seconds) |
|---|---|---|---|---|---|
| | Actual | Proposed Method | Actual | Proposed Method | |
| 3 | 208 | 88 | 551 | 132 | 3.596 |
| 5 | 328 | 214 | 781 | 349 | 4.3521 |

In the last, the proposed method is compared with the existing method in Table 4. The results show that the proposed method is superior to the existing method to reduce the load and cost factor.

**Table 4 Comparative Analysis with the Existing Method**

| Devices | Actual Cost | Sisodiya et al. [12] | Proposed Method |
|---|---|---|---|
| 3 | 551 | 328.44 | 132 |
| 5 | 781 | 568.33 | 349 |

## 6. CONCLUSION

A hybrid combination of BAT and PSO algorithms is used to build an energy management strategy in this research article. MATLAB is used to run the simulation, and several performance indicators are calculated. In comparison to the real load, the proposed solution saves 76.04 percent and 55.31 percent for 3 and 5 devices, respectively. In addition, when compared to Sisodiya et al. [12], the proposed strategy reduces the cost factor by 59.81 percent and 38.59 percent, respectively.

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