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Energy Management of a Single Grid-Connected Home Microgrid for Determining Optimal Supply/Demand Bids

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***Abstract*— As a result of socio-economic growth and paying attention to environmental aspects requirement in order to improve the reliability and achieve higher service, better power quality and increasing energy efficiency are taken more into consideration. Thus, home micro-grids (H-MG) with non-dispatchable Source and interruptible loads can be used as the primary tool to achieve the stated objectives. In order to implement the energy management system (EMS) an algorithm is presented in this paper. EMS which is based on harmony search method for multi-purpose extrapolation of a sample H-MG with renewable energy sources (RES) as well as compound resources of backup power such as micro-turbine and battery for levelling the mismatch of power or for additional power saving in case of necessary. In this paper, the harmony search (HS) for an algorithm to minimize the costs associated with sources, RLD and reduce the price of the electricity (i.e. market clearing price) with respect to the proposed price of production and supply, the price of non-interruptible loads, the optimal production of each of the existing resources in the micro grid is determined. For reliability enhancement the uncertainty is considered in using wind turbines (WT), photovoltaic (PV), load demand and market clearing price in the algorithm. The recommended algorithm system is tested on a H-MG sample. These results show the capability of the HS approach in supplying the load requested.**

***Keywords*— Energy management system, Home-microgrid, Optimal bids, Demand respond;**

Nomenclature

	Maximum power generated by wind turbine at time t (kW)
$\overline{P}_t^{EX}$	Microgrid consumption capacity (£/kWh)
	Maximum power of photovoltaic (solar) unit at time t (kW)
π_t^{WT}	Offered price by wind turbine (£/kWh)
$\underline{MT}$	Minimum power generated by micro turbine (kW)
π_t^{PV}	Offered price by Photovoltaic (£/kWh)
$\overline{MT}$	Maximum power generated by micro turbine (kW)
π_t^{MT}	Offered price by micro turbine (£/kWh)
$\overline{P}_t^{ES-}$	Maximum power consumed by storage system at time t (kW)
$\pi_t^{DR+,-}$	Offered price for demand respond in respond/shifted mode (£/kWh)
$\overline{P}_t^{ES+}$	Minimum power consumed by storage system at time t (kW)
π_t^{EWH}	Offered price for selling power to thermal unit (£/kWh)
$\underline{E}_t^{ES}$	Minimum energy stored in storage system at time t (kWh)
π_t^{ES+}	Offered price by ES for buying from microgrid (£/kWh)
$\overline{E}_t^{ES}$	Maximum energy stored in storage system at time t (kWh)
π_t^{ES-}	Offered price by ES for selling power to microgrid (£/kWh)
E_{Tot}^{ES}	Total battery capacity (kWh)
π_t^{UP}	Offered price for load not supplied by microgrid (£/kWh)
Δt	Time step (1 hour in this paper)
π_t^{Grid+}	Offered price for selling power to the GRID (£/kWh)
X_t^{DR-}	Shiftable power decision making variable {0,1}
π_t^{Grid-}	Offered price for buying power from microgrid (£/kWh)
k_ϵ	Ratio between maximum shift able power and load demand at time t (kW)
k_t	Upper and lower limit for the variations of power value shift able at time t (kW)
r	A coefficient of total microgrid capacity (%)
X_t^{DR+}	decision making variable of respondable power {0,1}
β, γ, ϕ, α	Price coefficient

I. Introduction

In recent years because of the high energy demand, using renewable energy sources such as wind, solar etc. is vital important. This is to increase reliability, improve power quality and power supply flexibility. Reducing prices, and lowering environmental impacts is also important to develop energy management system (EMS) in the home-microgrid (H-MG) [1], [2], [3], [4]. Distributed energy and storage resources (DESR) are small energy resources that are placed next to the loads and can be divided in two groups, including distributed generations (DGs) and distributed storage (DS) units. Systems including DESR that can function in two-modes of operation: isolated type and grid connected type. This is called H-MG micro grid [5], [6]. The H-MG has different sets of electrical loads, non-responsive load (NRL), responsive load demand (RLD), thermal loads and DESR units which are employed by a distribution networks. In islanded operating mode, H-MGs can resume their normal operation. The management of H-MG units needs a detailed economic model to explain the extrapolation cost, taking into consideration production resources output power [7], [8]. The proposed model is non-linear model and has discrete nature; therefore, the suitable optimization tool is to minimize the cost of extrapolation is required. Some economic advantages of the H-MG are stated below:

- Reduce the cost of transmission, distribution and energy losses
- Potential for having higher energy efficiency
- Low cost of private section investment resulting from reducing investment risk
- The potential for low investment costs, entry of low cost system to a possible competitive market.
- Converting the vertical ownership of generation, transmission and distribution to competitive companies

In order to control H-MG and achieve the stated objectives, it is necessary to design energy timing scheduling and suitable energy and operation scheduling (EOS) for the system. The different studies are proposed for implementation of the EOS in H-MGs [9]. In [10] an intelligent energy management system using genetic algorithms to optimize the performance of H-MG is suggested. In this paper, an EMS based on optimization technique is developed to utilize better energy storage in the H-MGs. In [11] load demand related to two H-MGs including wind farm is modeled using an optimal power flow and PSO algorithm. In this paper, it is shown how the saved energy can be sold at a higher prices and peak shaving can reduce total operating costs. In order to reduce the fuel consumption of resources considering the local both electrical and thermal load demand as well as the minimum reserve power is completely introduced in [12]. H-MG performance in the grid-connected mode, using production optimization of the DGs units and exchange power with upstream grid is optimized in [13]. In addition, a linear program is available to minimize the average cost of electricity power generation in a solar-wind hybrid H-MG taking into account the constraints related to weather conditions, and this is already proposed in [14]. In this paper, an accurate and efficient method is proposed and assigned to study a grid-connected H-MG according to operation costs and reduce the cost of electricity. H-MG studied can operate as isolated and grid-connected. Grid-connected H-MG can purchase the part of its claimed power from the upstream grid in the case of mismatch power between generation and consumption. Moreover, part of the surplus generated by H-MG can be exchanged to the grid at overproduction times. The author also has followed solving the optimization problem by applying several scenarios to search for the optimal management technique for energy. The Search is based on the minimization of executive costs. It is expected to cover a load demand scenario in H-MG. It will be shown that a good model using a suitable optimization algorithm can be employed for solving the optimization problem with accuracy and high efficiency. Optimization method based on optimization explicit criteria; minimize extrapolation costs related to H-MG architecture to the least amount possible. Based on the input data including actual data measured related to non-responsive load (NRL) and bids related to any of the H-MG equipment, optimization algorithms choose required optimum power for available loads as well as tiny resources involved in H-MG in the best economic conditions possible. In addition, the proposed algorithms in each iteration determine the most optimal conditions for the use of any production source [15]. If power produced from wind turbines and photovoltaic times is fewer than the demand, then the algorithm will go to the next stage and will use alternative resources (based on the load and the cost function). Search methods presented are designed that use only the amount of functions and only need a number of objective need and do not need the knowledge and realizing the internal structure of matter. The proposed algorithms can easily be generalized to discrete problems, nonlinear, non- convex or applicable non-differential. These algorithms are generalized well in conditions that objective function is noisy, expensive, discrete, and non-differential and is non-predictable at some points.

II. Structure of H-MG

As displayed in fig.1, the system studied below is considered as grid-connected including non-dispatchable (the WT and the PV) and dispatchable generation resources (the MT) and ES supplying some responsive loads (the EWH and the DR). The MT and ES are in order backup system and energy storage system. At this H-MG, to Evaluate different concepts such as Variety of control methods, EMS implementation is used [5], [1],[7].

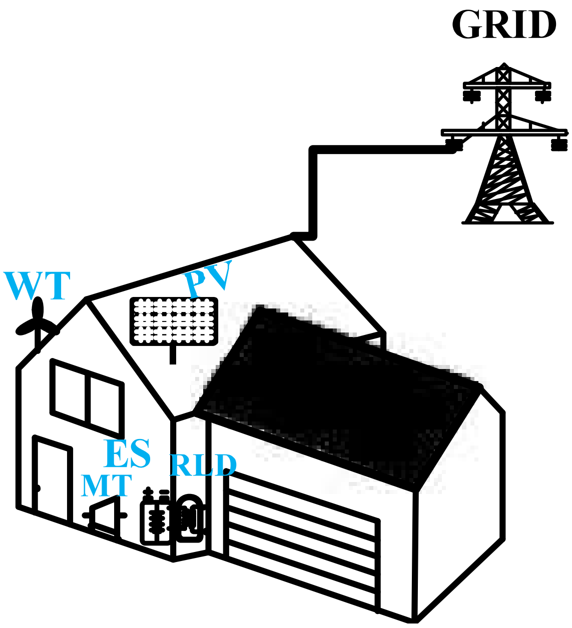


Figure 1: diagrammatic of the H-MG system under study

III. Problem formulation

The optimization problem is determined according to Eq.1:

$$\max \sum_{t=1}^{24} \left(\begin{array}{l} \sum_{k=1}^{n} P_{t,k}^{WT} \times \pi_{t,k}^{WT} + \sum_{j=1}^{p} P_{t,j}^{PV} \times \pi_{t,j}^{PV} + \\ \sum_{q=1}^{m} P_{t,q}^{MT} \times \pi_{t,q}^{MT} + \\ \sum_{f=1}^{b} P_{t,f}^{DR-} \times \pi_{t,f}^{DR-} - \sum_{a=1}^{e} P_{t,a}^{EWH} \times \pi_{t,a}^{EWH} - \\ \sum_{z=1}^{h} P_{t,z}^{DR+} \times \pi_{t,z}^{DR+} - \\ \sum_{x=1}^{c} P_{t,x}^{ES+} \times \pi_{t,x}^{ES+} + \sum_{y=1}^{d} P_{t,y}^{ES-} \times \pi_{t,y}^{ES-} - \\ \sum_{u=1}^{o} P_{t,u}^{Grid-} \times \pi_{t,u}^{Grid-} + \\ \sum_{s=1}^{v} P_{t,s}^{Grid+} \times \pi_{t,s}^{Grid+} + \sum_{w=1}^{r} P_{t,w}^{UP} \times \pi_{t,w}^{UP} \end{array} \right) \times \Delta t \tag{1}$$

Where n is the number of WT, p is the number of PV, m is the number of MT, b is the number of times that loads will be shifted to other times, e is the number of times that EWH will be fed, c is the number of times that ES will be discharge, d is the number of times that ES will be charged, r is the number of times that the loads will not receive a response, o is the number of times that power will be sold to the gird, v is the number of times that the power will be bought from grid, h is the number of times that the load will be shifted, will receive a response. Operational constrains

- **Non-dispatchable sources**

$$P_t^{WT} \leqslant \overline{P}_t^{WT} \tag{2}$$

$$P_t^{PV} \leqslant \overline{P}_t^{PV} \tag{3}$$

Where $\overline{P}_t^{WT}$ and $\underline{P}_t^{WT}$ are maximum forecasted generation units by non-dispatchable source at time t.

- **Dispatchable source**

$$\underline{MT} \leqslant MT \leqslant \overline{MT} \tag{4}$$

Where $\overline{MT}$ and $\underline{MT}$ the highest and the smallest capacity of the power by micro turbine responsively.

- **ES constrains**

$$P_t^{ES-} \leqslant \overline{P}_t^{ES-} \tag{5}$$

$$P_t^{ES+} \leqslant \overline{P}_t^{ES+} \tag{6}$$

Eq.5 appearances that when ES is in the discharge style, the discharging power cannot pass the maximum charging power of the ES. The same procedure property is determined for the charging style, which is given in Eq.6.

$$\overline{E}_t^{ES} \leqslant E_t^{ES} \leqslant \underline{E}_t^{ES} \tag{7}$$

Where $\overline{E}_t^{ES}$ and $\underline{E}_t^{ES}$ are maximum and minimum energy storage in ES.

$$SOC_t = \frac{SOC_t^{ES}}{SOC_{Tot}^{ES}} \tag{8}$$

$$SOC_{t+1} = \left| SOC_t + \frac{(P_t^{ES+} - P_t^{ES-}) \times \Delta t}{E_{Tot}^{ES}} \right| \tag{9}$$

After each charging or discharging, shall check state of ES.

- **Demand respond constrain**
  - Total consumption power
$$P_t^{TCP} = P_t^{n} - \overline{P}_t^{DR-} + \overline{P}_t^{DR+} + \overline{P}_t^{Grid+} + \overline{P}_t^{ES+} + \overline{P}_t^{EWH} \tag{10}$$
  - Total generation power
$$P_t^{TGP} = P_t^{WT} + P_t^{PV} + P_t^{MT} + P_t^{Grid-} + P_t^{ES-} \tag{11}$$
  - Total execs generation power
$$P_t^{EGP} = P_t^{ES+} + (1 - X_t^{DR+}) \times P_t^{DR+}, X_t^{DR+} \in \{0,1\} \tag{12}$$
    At Eq.12, execs generation in time t is and is a binary variable for DR status.
  - Shiftable power constrain
$$P_t^{DR-} \leqslant (P_t^{TCP} - P_t^{TGP}) \times X_t^{DR-}, X_t^{DR-} \in \{0,1\} \tag{13}$$

Eq.13 Shows that shiftable power value must be less equal to the difference between the total consumption power

$$P_t^{DR+} \leqslant (P_t^{TGP} - P_t^{TCP})(1 - X_t^{DR-}), X_t^{DR-} \in \{0,1\} \tag{14}$$

$$P_t^{DR+} \leqslant k_e \times P_t^{n} \times (1 - X_t^{DR-}), X_t^{DR-} \in \{0,1\} \tag{15}$$

$$-k_t \leqslant P_t^{DR+} - P_{t-1}^{DR+} \leqslant k_t \tag{16}$$

To allow a regular shift for the final demand curve, some limitations are applied. These limitations are described by a bound in the demand that can be displaced and bound for the slope of the curve expressed by Eq.14 to Eq.16 respectively

- **Interactive power constrains between grid and H-MG**

$$P_t^{\text{Grid-}} \leqslant \overline{P}^{\text{Ex}} \quad (17)$$

$$P_t^{\text{Grid+}} \leqslant \overline{P}^{\text{Ex}} \quad (18)$$

Eq.17 to Eq.18 shows that the H-MG cannot buy or sell power more than $\overline{P}^{\text{Ex}}$.

$$\overline{P}_t^{\text{Ex}} \leqslant r \times \left(P_t^{\text{WT}} + P_t^{\text{PV}} + P_t^{\text{MT}} + P_t^{\text{ES-}} \right) \quad (19)$$

In order to restrict the transfers with the grid and using efficiently resources in H-MG; Eq.19 is considered.

- **Power balance**

$$\overline{P}_t^{n} - \overline{P}_t^{DR-} + \overline{P}_t^{DR+} + \overline{P}_t^{Grid+} + \overline{P}_t^{ES+} + \overline{P}_t^{EWH} = \overline{P}_t^{WT} + \overline{P}_t^{PV} + \overline{P}_t^{MT} + \overline{P}_t^{Grid-} + \overline{P}_t^{ES-} \quad (20)$$

- **Undelivered power**

$$\overline{P}_t^{UP} = \overline{P}_t^{TGP} - \overline{P}_t^{TCP} \quad (21)$$

- **Bidding constrain**

$$\alpha \leqslant \pi_t^{PV} \leqslant \beta \quad (22)$$

$$\alpha \leqslant \pi_t^{WT} \leqslant \beta \quad (23)$$

$$\alpha \leqslant \pi_t^{ES-} \leqslant \beta \quad (24)$$

$$\alpha \leqslant \pi_t^{ES+} \leqslant \beta \quad (25)$$

$$\pi_t^{UP} = \gamma MCP \quad (26)$$

$$\pi_t^{MT} = MCP \quad (27)$$

$$\pi_t^{DR-} = MCP \quad (28)$$

$$\pi_t^{DR+} = \beta MCP \quad (29)$$

$$\pi_t^{Grid+} = \gamma MCP \quad (30)$$

$$\pi_t^{Grid-} = \gamma MCP \quad (31)$$

$$\pi_t^{EWH} = \phi MCP \quad (32)$$

IV. Harmony search algorithm

Harmony search algorithm in 2001 by Zong Woo Geem through inspired how the formation and how the musician's operation was designed and presented. As in orchestra musicians playing musical parts to choose the best final production amongst the composition of them, harmony search also reviews results of the components performance for desired coordination. Harmony search algorithm according to the appropriate structure, including consumer good memory and also less dependent on sophisticated knowledge of mathematics, optimal flexibility and better solutions to achieve optimal response, it is better than the previous similar ways. This algorithm solves the issues of the continuous variables, as well as combined solutions. It was found in the conducted experiments to find the optimal response, it was found that harmony search algorithm performance as compared to the performance of the genetic algorithm (GA) and simulated annealing (SA) is much better; in a way that speed to reach optimal response by HS against GA and SA became 63 and 224 times, respectively [16].

A. Algorithm steps

Step 1: making initial responses and filling harmony memory (HM) at this stage, a harmony memory is formed, which will be store the location of the responses obtained from the solution at each stage. Also in this step, harmony memory is filled with random, by initial responses that should are in the range of possible answers.

Step 2: Generate New Harmony

a. With probability harmony memory consideration rate will be used for HM coordinates.
b. With a probability of 1 HMCR will be made with random numbers.

In this stage, new responses are generated where these new responses with probability of HMCR and 1 are obtained from existing responses in harmony memory. This paper is done with HMCR probability.

Step 3: modify frequency of new harmonies

a. With probability of Pitch Adjustment Rate (PAR) is created trivial changes in interested coordinate.
b. With probability of 1, PAR i will not have any changes.

This paper is done using PAR. probability

Step 4: compare New Harmony and adding it to HM in the face was better in this step, is added produced new responses to previous harmony memory. In this stage are compared added previous and new responses each other. Due to the capacity limitation of harmony memory capacity, the good responses are remained and the rest are discarded. The depletion of these responses and the good remained ones, in this stage are evaluated in a way that all of remained responses in this stage are converged to final answer of solution.

Step 5: return to second stage, if does not meet the end conditions At the last stage, the review of the iteration

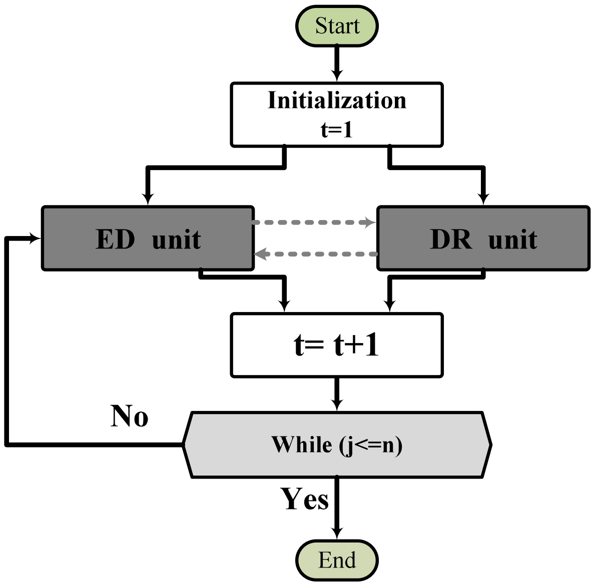


Figure 2: Recommended algorithm for performing the EMS

number required to meet the conditions is carried out, which if fulfilled, and this is when the calculation ends. In case of not fulfilling, then calculations will return back to the second step.

Advantages an disadvantages of HS algorithm compared with some optimization algorithms are explained by authors in [2].

V. EMS algorithm

According to fig. 2 this algorithm is composed of two units; economic dispatch (ED) and demand respond (DR) [5]. ED unit has the task of determining the optimal level of generation units in H-MG with the minimum cost of operation due to technical and economic constraints [17]. In DR unit, in order to reach a balance between the supply and the demand, also for power outages decrease in the grid by using demand respond shift at the time to another time that generation cannot supply the demand Since allocation loads can be various in unit generation and since reduction cost of power generation is important, so finding optimize generation energy unit is considered. As it can be seen from fig. 2 below, ED and DR units, they both provide exchange for manage and reduce the cost of production and reduce the price of electricity load demand use of dispatchable and non-dispatchable resources.

The problem is to find the optimal mounts of power output of photovoltaic (PV) units, wind turbine (WT), micro turbine (MT), energy saving (ES) and shift ability power and demand response (DR), which must satisfy the provisions necessary there. Variables for optimization problem, include $X_t^1=P_t^{WT}$, $X_t^2=P_t^{PV}$, $X_t^3=P_t^{MT}$, $X_t^4=P_t^{ES}$, $X_t^5=P_t^{DR}$ and $X_t^6=P_t^{Grid}$. Use of proposed algorithm with aim of optimization the above variables, leading to minimize the cost function of Eq.1. All of system components must meet the constraints. Variables are classified into two type of subordinate and autonomous variables. P_t^{MT}, P_t^{DR+}, P_t^{DR-} and P_t^{Grid} as dependent variables and P_t^{PV} and P_t^{WT} are considered as independent variables. WT and PV generations are as Non-dispatchable resources and online by changing weather status, output can be changed independent of load power or other generations. In regards to this issue and for system improvement reliability uncertainty is considered.

VI. Results and discussion

In this section the results obtained from evaluating the proposed algorithm on the H-MG under study are presented. Some of the outputs are analyzed in this section. In fig. 3 SOC value is shown during system daily performance. As it can be observed, SOC is higher than 50% in more than 60% of daily performance which states the very inadequate performance of the recommended algorithm in increasing system reliability during the day and also in intervals leading to the end of the day, SOC has its highest value which has also caused an increase in system reliability for the next day's performance. In fig. 4(b) power generation bar graph is shown in the system performance 24 hours interval. As it is observed, only in three intervals, H-MG has under taken selling power to the national grid. In these time periods the value of load demand is shorter than the value of the power generated by H-MG and as it is seen from fig. 6 first the proposed algorithms has charged ES and then responds to the value of the power shifted from the previous stage and finally has sold the excess value to the grid. Also as for fig. 5(b), the best time to respond to the value of the shifted power is this internal because the value of MCP obtained by the algorithm is far shorter than the value of MCP. In interval 3 to 5, power shortage has existed, but because this amount of shortage is less than MT minimum amount has not brought MT algorithm to the circuit and first has compensated this amount of shortage in interval 3 by discharging ES but because this amount has first compensated shortage in interval 3 by discharging ES but because this value is more than maximum ES discharge power, has shifted it to the next intervals. In interval 6, because the amount of power shortage is more than its generation, and also the amount of shortage is more than the minimum capacity of MT, according to fig. 4(b), MT comes into circuit and has responded to this amount of shortage.

It can be observed, that the value of MT generation is more than the other generation resources, the MT proposed offer is accepted and affected by MT offer, MCP has had some little changes. In this interval the algorithm has allocated power excess value to charging ES and then, according to fig. 5(b) to a value of shifted power from the previous intervals. As it is observed from the 7^{th} intervals of fig. 4(b) and fig. 6, in these intervals, the values of power generation

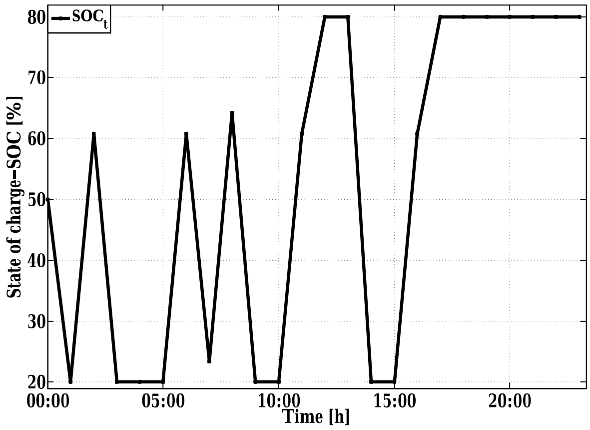
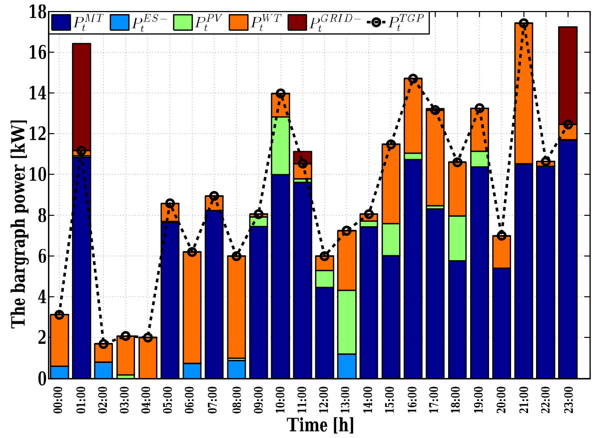


Figure 3: SOC throughout system daily operation

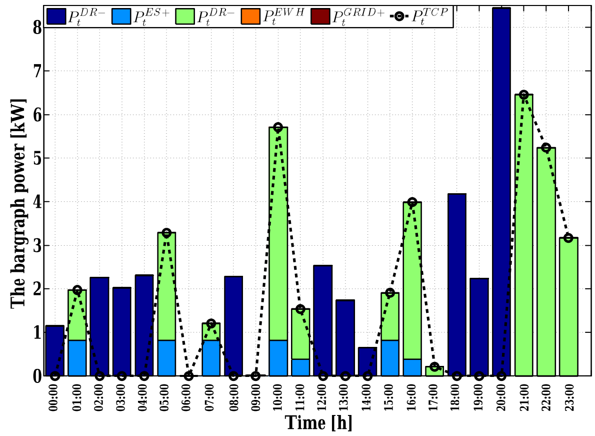
and consumption are equal to each other. But by observing fig. 5(b), the MCP value obtained by the algorithm has rose substantially. The reason is that the method, has adopted the offer related to ES- and MCP. The performance of interval 8 is the same as interval 6 with this difference in which response value to shifted load is less than interval 6 and if figure MCP is paid attention to, it is observed that the MCP obtained by the algorithm in interval 8 is less than the MCP obtained by the algorithm in interval 6.

In interval 9, H-MG has power shortage, but because this shortage value is less than MT minimum capacity and also the obtained MCP value is close to MCP, so, the proposed algorithm shifts shortage value to other intervals. In interval 10, power shortage value is 0.02 in which the algorithm transfers it to the next intervals. In interval 11 because we have excess power generation and also the MCP price calculated by the algorithm is a small value, so the algorithm at first responds to the ES and then responds to the DR which is related to the previous intervals, this is the most responsiveness to DR. In interval 12 again the generation value is more than the consumption. As for the calculated MCP price, the algorithms again respond to the DR because it responded to the main part of DR in the previous interval, after DR response in this interval, has allocated the extra amount of power to selling to the grid, as you observe in fig. 5(b), up to this moment, the amount of DR+ and DR- have become equal to each other.

In interval 13 to 15, as generation shortage has existed and also the buying offered price from the grid is increased, has shifted power shortage algorithm to other intervals. In intervals 16 to 18, due to the increase in the generation amount of MT and WT, the algorithm has well covered the amount of DR+. As it is observed in interval 17, as the amount of calculated MCP is much less than MCP, the highest DR+ has existed in this interval. In intervals 19 to 21, as it is observed from fig. 5(b) the MCP value is at



(a) Power generation

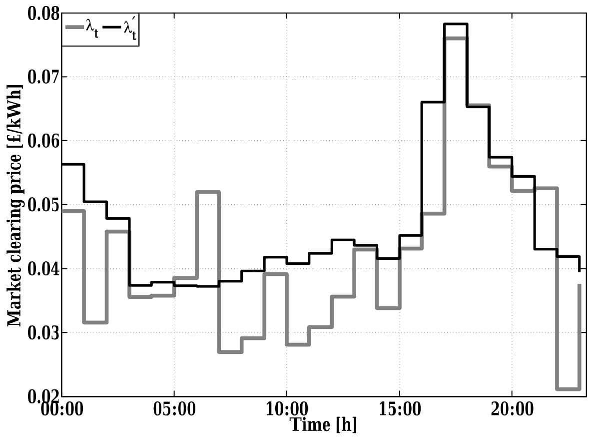


(b) Power consumption

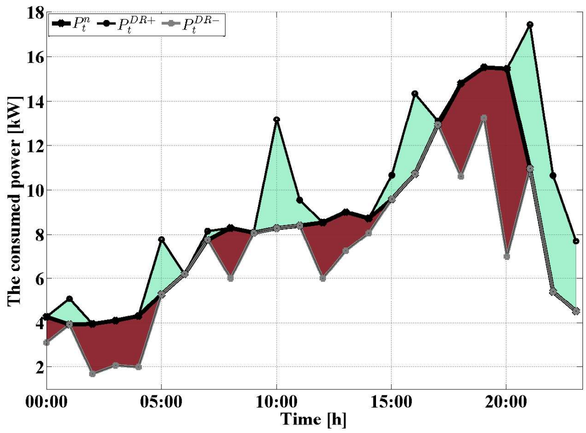
Figure 4: Generated and consumed power bargraph in the system with 24 hours interval

its maximum amount. As a result of this, the proper thing was that the algorithm has reduced the value of its demanded load power demand as much as possible and transferred it to another time interval. In the intervals 22 to 24, generation has increased in which this amount of generation is more in interval 22 than the rest and as it is observed in Fig. 6 in this interval the most responsiveness to DR exists. As for the MCP figure, the amount of MCP calculated by the algorithm is more than MCP value which means that the MT proposed offer is accepted. In interval 24 as for the complete responsiveness to the shifted power, the amount of excess generation is sold to the grid.

The isotropy characteristic of the HS algorithm is compared with common PSO algorithm in figure 6. this chart suggested that the recommended algorithm based on the PSO algorithm exceeds the HS algorithm in isotropy rate; nevertheless, the HS method obtained a higher operation in the optimization of the objective function. The maximum



(a) MCP during System Daily Performance



(b) The profile related to DR+ and DR-

Figure 5: Generated and consumed power bargraph in the system with 24 hours interval

repetition number for this case is set to 300 iterations.

VII. Conclusion

In this paper, objective function has been presented in a new form for determining optimum performance in H-MG by including the simultaneous load demand supply. By adding some constraint to the optimization problem, considerations have been done for fulfilling the desired objectives. The objective function has increased the economic power distribution constraints by defining the coefficient inserted in cost function. The proposed algorithm is capable in controlling optimization problem in order to satisfy technical and economic constraints and reach defined objectives. In order to reach this objective, harmony search algorithm for solving the problem of distributing optimum power in home-microgrids has been discussed. The results obtained from the optimum performance cost in H-MG, shows the sufficient operation of the suggested optimization method in

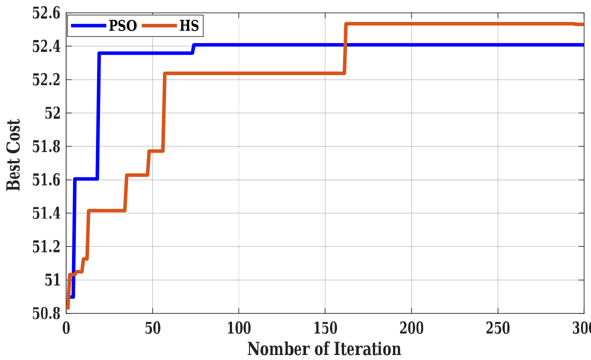


Figure 6: Convergence characteristic of the HS and PSO algorithm

better convergence to more adequate solutions, acceptable answers under different scenarios, raising reliability and the ability of the algorithm in solving discontinuous economic power distribution, Non convex and constrained problems. The main advantage of energy management is based on HS in its fast convergence to answer; the case which is very important in the problems related to instantaneous energy management. The ability of the proposed method in conformity of optimum conditions inserted in the contract and the results obtained from the algorithm are approved. These results demonstrate that the proposed approach in this paper has good efficiency in reducing the costs and supplying the need of the consumers under these conditions. The proposed algorithm can also be generalizable under the conditions of variations of consumed loads, in systems with larger size and also a change of different time seasons for more than one day.

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