Energy Management by Using Renewable Energy Sources

B. Bajibabu Naik, M.Rambabu

Abstract*: *Energy feasibility of power system is a multi-objective and various constraints problems in which energy management system, should have its range to take fast and strong commitment with regard to its report of produced by electrical energy from generating resources. This procedure for controlling energy management systems component by called as energy management system. For finding the actual time optimal energy management systems solution for standalone micro grid system consists of PV-MT-Battery-Windusing particle swarm optimization (PSO) is presented, which is biological inspired direct search method. Results shows for planned algorithm depends on energy management system attain different objectives such as: minimum price of generated electricity, maximal MT operating efficiency and minimal utility charges. The simulation results point out imperishable performance by particle swarm optimization for actual energy management.

Index Terms: Wind energy, photovoltaic (PV), Micro-turbine (MT), Battery bank, optimization methods, energy management.

I. INTRODUCTION

Progressively, efforts like price, natural worries, and technical obtain ability are applying effect on power system design and operation. Sectarian frameworks to mix varied resources & stockpile mechanisms in a micro-grid manner, called as energy management systems, to budding offer electrical customers the chance to tailor their connected assets to meet local supplies. Renewable energy power sources like wind energy and solar photovoltaic and developing slight or zero-productionpower sources schemes, like micro-turbine and fuel cells (FCs), drop in this group [1] [2]. Solar and Wind Generation (WG) components are broadly used to source power in isolated areas. Due to their complementary generation typical, wind/PV power systems are best option for electrical power formation, especially in separate application. This energy origin can accompaniment to reduce the changing the nature of the non-conventional energy sources and together with energy saving progress system consistency and energy balanced to the high range possible [3]. Real energy management system of hybrid energy schemes is needed to ensure optimal energy use and energy balanced to the extreme level. Still, given the intermittent environment of the renewable energy sources elaborate and the many objectives that essential to be satisfied, the management system (EMS) is complex and needs to find resolutions rapidly and unceasingly, example of every hour or less hour In this paper energy management of a hybrid wind & PV, Micro-turbine (MT) algorithm has been proposed to maintain the energy management in the renewable energy sources, while animatedly minimizing. To reduce generation cost and improve battery life by checking and controlling its (SOC) state of charge and discharge. In this paper destination the actual time request of experimental many objective optimization technical, particle swarm optimization (PSO) [4] as long as energy management of energy system. The block diagram of a Wind-Micro-turbine-PV Energy system with storage unit connected to utility as shown in figure1. The primary components of the given system are wind energy system that usesa induction generator with self excited, a individual-shaft micro-turbine generator (MTG) that incorporates an induction generator as well [5], PV & energy storage bank. The category of these devices used here study is given in fig.1. The maximum available power can be extracted from the PV and WG (wind generation) power sources The storage bank, it is used lead acid type, is recycled to store the energy spare and to supply the load by the case of very less wind speed and less irradiation situations. The MT (micro-turbine) is used when the mixture of wind energy conversion system (WECS), PV and storage bank power is not enough to supply the load. The revision described in this paper extension of a earlier work by authors [6-11] , previous the design of an energy management system wind-MT-ES is presented, still PV was not optimal technique used in that reference paper. In present paper, energy management particle swarm optimization (PSO)-based energy management for the micro grid system is considered.

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The impartial role for the expansion algorithm PSO used is changing each 1 hour, during which demand and sources are careful stable. The storage energy bank it was used safely and status of energy stable and to deliver the required power wanted throughout the each interval to cover short-period transients produced by unexpected varying in demand or WECS and PV. The enormously wild meeting speed of particle swarm optimization (PSO) [12] and the hopeful outcomes obtain show the possible of this many objectives in the real time energy management of several energy systems. It must be famous that the care of the stated work is on energy management, where 24-hour imitations are to be considered remained lead. In the paper element size, system voltage and frequency is not considered, will be reported in a upcoming effort. By this paper is prearranged as surveys. Invention of the optimal difficult is debated in Segment II. Segment III springs a report of the planned energy management system (EMS). In Segment IV, particle swarm optimization is clearly deliberated and, PSO built management system is obtainable. Imitation results are given in Segment V. A conversation is presented in Section VI and conclusions are given in Segment VII.

II. OPTIMIZATION PROBLEM FORMULATION

The equitable purpose improve for the energy management system obtainable here considered into the account a number of factor including the price of energy produced by the wind energy conversion system and micro-turbine as fine as the utility technical restraints of the optimization technique. For the micro-turbine, wind energy conversion system required restrictions are established.

A. Micro-turbine Cost Function and Restraints

The micro-turbine price function can be as monitors [9]

$$\sum_{t=1}^{t=24} Ft,MT = C_{Mt}\, F_{MT} \sum_{t=1}^{t=24} Pt,MT\Delta T + \sum_{t=1}^{t=24} OM_{t,MT} + \sum_{t=1}^{t=24} SC_{t,MT} \quad (1)$$

Where,

$F_{t,MT}$ = Total Operational price of micro-turbine

C_{MT} = Micro-turbine fuel cost ($/m^3), Normal cost of gas 0.36

F_{MT} = Consumption rate of fuel (m^3/kWh), F_{MT} = 0.0009

$P_{t,MT}$ = Micro-turbine output power of decisions variable

ΔT = Represent for step time by EMS as 1 hour

$OM_{t,MT}$ = Micro-turbine cost by operating maintenance ($)

$SC_{t,MT}$ = start-up cost of the micro-turbine units ($)

The operation and maintenance is expected to be proportional with the formed energy [10]

$$\sum_{t=1}^{t=24} \mathrm{OMt}, Mt = Koc \sum_{t=1}^{t=24} Pt, MT\ \Delta T$$

Here Koc is taken as 0.000006 $/Wh for the MT

$OM_{t,MT} = Koc.P_{t.MT}\,.\Delta T$ (2)

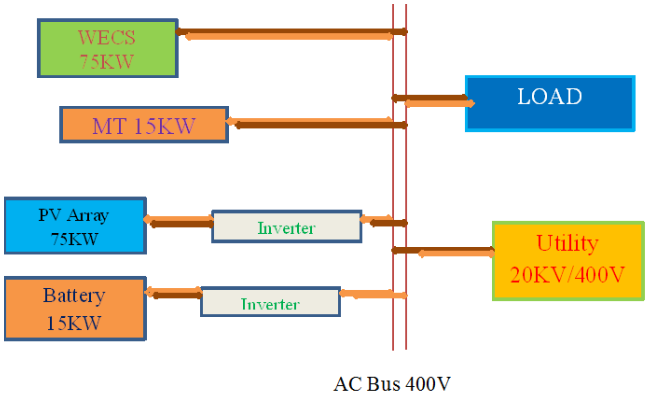

Fig. 1

The start-up cost of the micro-turbine is depends by the distance of time component has turn off earlier going op one more [15]

$$\sum_{t=1}^{t=24} SC_{t,MT} = (\sigma_{MT} + \delta_{MT}\left(\frac{1-e-\tau_{off,MT}}{\tau_{MT}}\right))(1\text{-}u_{(t-1),MT}) \quad (3)$$

Where $\boldsymbol{\sigma}_{MT}$ are the burning start-up

$\boldsymbol{\delta}_{MT}$ cool start-up price for micro-turbine,

if cool start-up of the micro-turbine necessitates power to run the micro-turbine supplementary schemes, then the wind energy or energy storage bank is compulsory to offer this cool star-up power. In over-all, for optimal study that comprise micro-turbinecool and hot start-up price would be comprised, though, in this specific circumstance, the worth of these parameter does not effects the results of optimization, due to the micro-turbine fuel cost is continuously greater than the entire cost of operational wind energy conversion system. Unavailability of data for emission cost, so emission cost has not been considered in this work. In this case, the available maximum power from the micro-turbine is 15 kw that the micro-turbine could be turn on and off when the power output of the wind system is sufficient to meet the demand power. When the micro-turbine turned on ($ut,_{MT}$ = 1), it works continually for a certain time before it turns off ($ut,_{MT}$ = 0). The following constraints are framed as continuous start/rest time as surveys:

1) Estimate the micro-turbine maybe put OFF by likening the ON-time of the micro-turbine in the earlier steps of the energy management system with the micro-turbine's least on-time (MUT)

If (T^{on} – MUT) ≥ 0,

Then T^{on} = 0, $ut,_{MT}$ = 0 (4)

2) Estimate whether the micro-turbine may be ongoing by likening the OFF time of the micro-turbine in the earlier time steps with the MT's minimum down-time (MDT)

If (T^{off}– MDT) ≥ 0,

Then T^{off} = 0, $ut,_{MT}$ = 1 (5)

Where T^{on} and T^{off} are the time distance the micro-turbine has been ON or OFF, correspondingly. Here we revision the MUT = 600s, and MDT = 300's [15].

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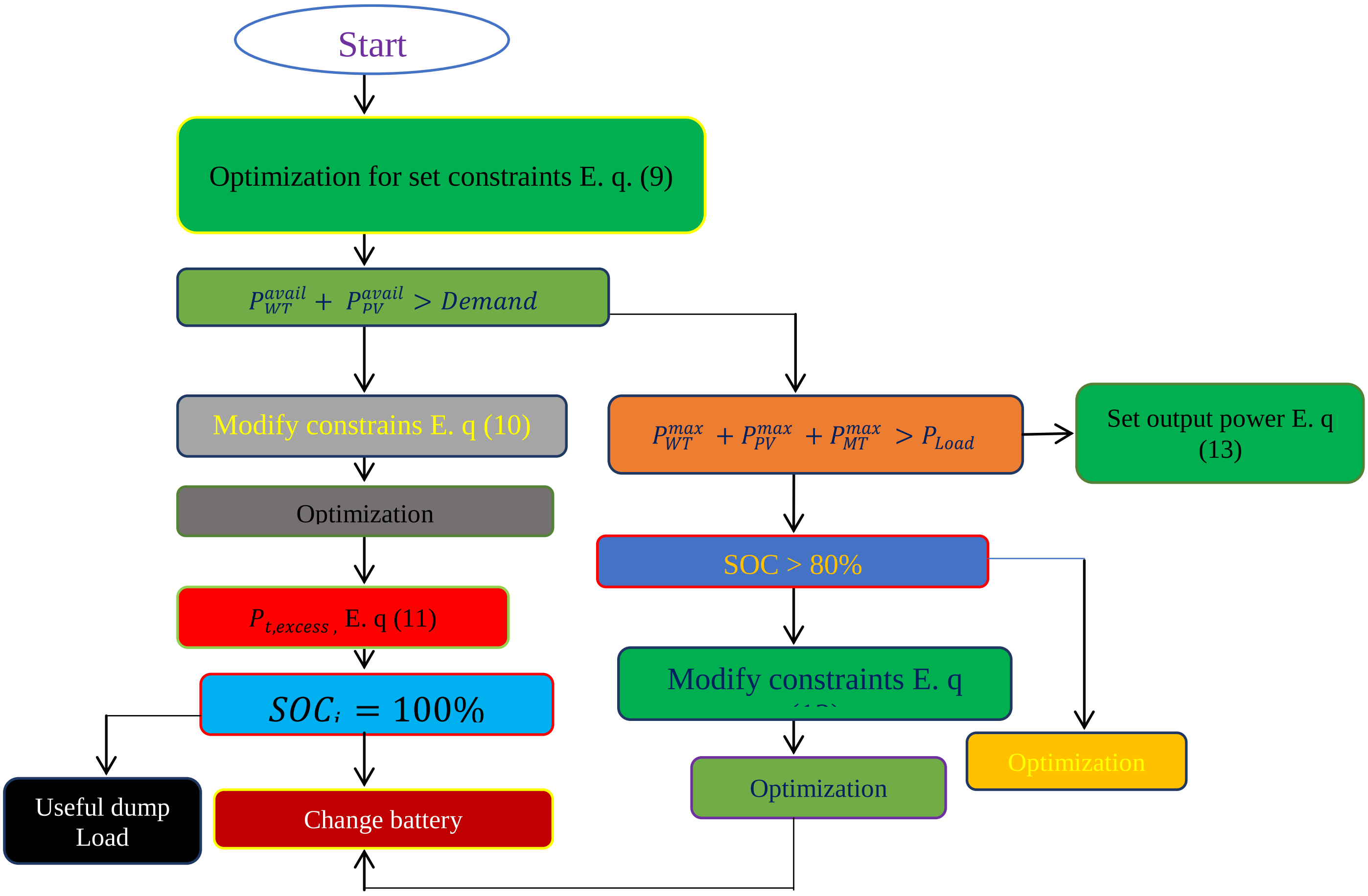

Fig. 2 The proposed energy management system formulation wind energy and photo voltaic, micro-turbine and energy management system

B. Wind energy price Purpose And Constrictions

The price function is used for WECS (wind energy conversion system) [12]

$$F_{t,Wt} = (Cwt.Pt, WT.\Delta T) \quad (6)$$

Where $F_{t,Wt}$ is total cost of wind-generation energy, Pt, WT and Cwt are the wind energy conversion system wind power and its price fixed for the produced energy at every period step ($/kwh), similarly. In this reading, Ft, WT is continuously less thanFt, MT. The cost of C_{WT} be contingent on the definite price of the wind energy-generation energy, where this circumstance, is occupied by way of $0.1/kwh. Over this issue will not disturb the outcomes then $F_{t,WT} < F_{t,MT}$. For WECS output power of limited founded on its power curve and limits. The sub sequent limits are used in this learning [13].

1) Cut in speed, v_{cut-in} = 3 m/s
2) Rated speed, $v_{cut-out}$ = 14 m/s
3) Cut-out speed, $v_{cut-out}$ = 25m/s

The wind energy conversion system it's not make any switch for $v_{wind} < v_{cut-in}$ Arena controller is used to limit the o/p of the wind energy to its rated value (75KW)

When $v_{rated} < V_{cut-out}$, and the wind energy output power is zero for $v_{wind} > V_{cut-out}$. In this instant the wind energy production power is intended at every time step by the power stability for the wind & PV and to meet weight demand is$p_{t,WT} + p_{pv} = p_{t,Load}$ * $0_{\le} p_{t,WT} \le pt, WT^{max}$ (7)
Where Pt, wt^{max} is the wind-turbine of rated output power The assessments of these mechanisms castoff in this study are given in the fig. 1. Though the planned real time energy management when the PV & WG (wind generation) < Load, the battery is discharging condition. And also when the PV & WG > Load, the battery is charging condition. If does not enough to supply the load to combination of PV, WG & battery not equal to load then MT(micro-turbine) is turn on.
The primary objectives as monitors

1) Reduce energy generation cost;
2) Improve the life of battery and nursing & regulatory, its state of care (SOC) & process care/release;
3) Exploit the usage of spare offered wind energy & PV in a suitable junkyard load when the energy bank is completely charged in an effort to increase system operation [18];
4) Exploit the battery usual offered stored energy in the battery (that battery SOC) [19];

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5) Once the micro-turbine is in operation, regulate its process points to nearby its regarded power to rise is procedure effectiveness and decrease its green impact.

$$P_{t,WT}^{max} = P_{t,WT}^{avail}, P_{WT}^{min} = 0,$$
$$P_{t,PV}^{max} = P_{t,PV}^{avail}, \quad P_{PV}^{min} = 0,$$
$$P_{MT}^{rated} = 15\,kw, P_{t,MT}^{min} = 0, \quad (9)$$
$$P_{t,supply} = Demand_{t,}$$
$$P_{t,supply} = P_{t,WT}^{optim} + P_{t,PV}^{optim} + P_{t,MT}^{optim} \pm P_{t,batt}$$

- Where $P_{t,WT}^{max}$ and $P_{t,WT}^{min}$ are the power limitation for maximum and minimum to the WT (wind-turbine);
- $P_{t,PV}^{max}$ and $P_{t,PV}^{min}$ power limitation for maximum and minimum to the PV;
- P_{MT}^{rated} and P_{MT}^{min} power limitation for the rated and least of the MT (micro-turbine);
- $P_{t,supply}$ total supply of the load
- $Demnd_t$ stands total power demand by the load at a time t;
- $bP_{t,WT}^{optim}$, $P_{t,PV}^{opim}$ and $P_{t,MT}^{optim}$ remain the improved share of the wind energy conversion and PV, the micro-turbine is later optimized;
- $P_{t,battery}$ it is sum of charging and discharging power from the battery-operated.

as shown in figure 2, the total load getting from wind and pv available output power, if we have additional power from the PV and wind it will be stored to the energy bank if necessary. Otherwise useful dump load, equation (7)

$$P_{t,supply} = P_{t,WT}^{avail} + P_{t,PV}^{avail} \quad (10)$$

The additional power is the difference between the total generation and demand, after complete performing optimization.as follows.

$$P_{t,excess} = P_{t,WT}^{optim} + P_{t,PV}^{opim} + P_{t,MT}^{optim} - Demand_t \, 11$$

If the battery was very low less than 80% then extra power will castoff to store energy bank. Otherwise the energy bank will be remains in active and additional power is direct to dump load.

$$P_{t,battery}^{min} = 1 \; P_{t,supply} = P_{t,WT}^{max} + p_{t,PV}^{max} + P_{t,MT}^{raed} \quad (12)$$

This expression means if we have leftover power it resolve used to energy storage bank, which can increase the dependability of the entire arrangement, resultant improve energy stable. Giving to [20] boosting lead-acid batteries proximately after clearing will extend battery life sensitively. So as to evade accusing the battery some very little currents, in this case wind, PV and micro-turbine if not sufficient to cover demand than energy bank is need to cover the load demand

$$\begin{cases} P_{WT}^{optim} = P_{WT}^{avail} \\ P_{PV}^{optim} = P_{PV}^{avail} \quad (13) \\ P_{MT}^{optim} = P_{MT}^{rated} = 15\text{ kw} \\ P_{battery} = \text{Demand} - P_{WT}^{optim} - P_{PV}^{optim} - P_{MT}^{optim} \end{cases}$$

Here the techniques used by PSO in energy management system its described segment IV, the optimization technique base energy management system is described in segment IV-

III. PSO (OPTIMIZATION TECHNIQUES)

This technique is achieved at the every period stage (1 hour) the control technique used by the energy balance PV & micro-turbine to meet required demand power. The input optimization technique values of wind energy conversion data and PV irradiation data, energy storage bank data in the optimization block. By suddenly changing in demand power PV and wind energy speed happen throughout technique, the energy storage bank will care of the power transients. [20] [21], inspired by social conduct of bird gathering, fish schooling & swarm concept. PSO stocks many comparisons with techniques like GAs (genetic algorithms). Each element is stared as point in a d-dimensional space that correct 'in the air' according to its own hovering knowledge and hovering incident of additional swarm optimization, it is simple idea.

A. PSO- based on energy management system

To apply PSO to the WECS-PV-MT energy management problem at hand, $P_{t,MT}$ and $P_{t,BAttery}$ are selected as decision variable to be optimized by PSO.$P_{t,MT}$ is then computed using the equality

$$\begin{cases} P_{t,MT} + P_{t,WT} + P_{t,PV} + P_{battery} = P_{t,Load} - P_{t,util} \\ 0 \leq P_{t,WT} \leq P_{t,WT}^{max} \; (14) \end{cases}$$

Where $P_{t,WT}^{max}$ is the rated power output power of the WT. Initial particle swarm optimization optimized by every step

$$P_{t,MT} = \text{rand}\,()\left(P_{t,MT}^{max} - p_{t,MT}^{min}\right) + P_{t,MT}^{min} \quad (15)$$
$$P_{t,battery} = \text{rand}\,()\,(P_{t,battery}^{max} - p_{t,battery}^{min}) + p_{t,bat}^{min}$$
$$\text{For } 1 \leq t \leq 24$$

Where rand () signifies unchanging random numbers between 0 and 1, the battery which is proportional to its sate of charge is $p_{t,MT}^{max}$ maximum power from the MT and $P_{t,battery}^{max}$ is from maximum power to the battery, which is proportional to its state of charge.

Where, $P_{t,battery} \leq 0$is discharging condition

$P_{t,battery} \geq 0$

is charging condition

The total utility power can be calculated as follows,

$$P_{t,Util} = P_{t,Load} - (P_{t,MT} + P_{t,WT} + P_{t,Pv} + P_{Battery}) \; (16)$$
$$\text{for } 1 \leq t \leq 24$$

Here two energy supervision situations to be measured Case 1 & case 2.

Case 1: No optimization, wind energy conversion system WECS-PV-MT (micro-turbine), Here load demand is taken output from wind energy, by the additional power if we have it is use to energy storage bank in case its not full, if it is charging 100% or else limited required by the load from the wind energy output power. By the combination of wind and PV, battery if not meet load demand that time micro-turbine is on. Maximum power dispatch equation for the WECS maximum power as well as PVs maximum power, as follows equation;

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$$\text{IF} P^{avail}_{t,WT} + P_{t,PV} > P_{t,Load} \text{ AND} SOC_t = 100\% \rightarrow P^{max}_{t,WT} + P_{t,PV} = P_{t,Load} \quad (17)$$

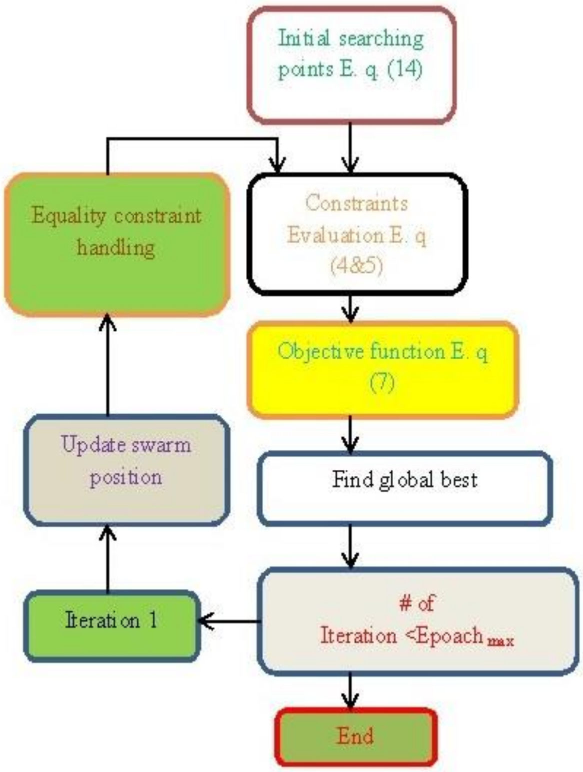
$$\text{else } P^{max}_{t,WT} = P^{avail}_{t,WT}$$

Where, $P^{max}_{t,WT}$ is the rated output power that is needed to cover rest of $P_{t,Load}$

$P^{avail}_{t,WT}$ is the rated output power of wind turbine.

Case II, This is preferred for energy management strategies, here wind energy is deliver the load, when the additional power we have its will be used to energy storage bank, if energy storage bank was 100% charge its will used to useful dump load.

Fig. 3 flowchart of the proposed PSO algorithm



Load & Utility: The distribution of the consumer power requirement during a day. As shown in fig. 4. The distribution power requirement during the day of the consumer similar to size of the load is multiplied by 250 Watt-hour. As for fig. 4 the peak load is 10am 15pm, the maximum peak is 1pm 220 kw peak. The distribution of the power requirement in peak time can manage the load scheduling; advantage is tariff price can reduce the peak demand

IV. RESULTS AND DISCUSSIONS

CONNECTED TO UTILITY BUY- SELL;

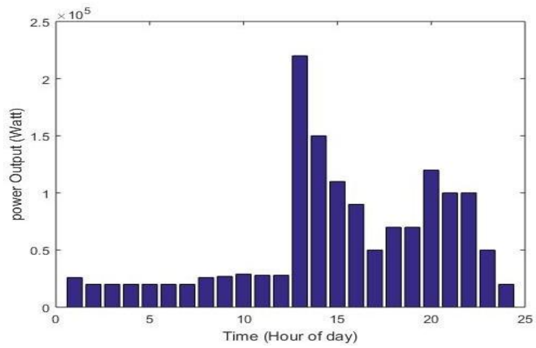
BatteryP_{rated} = 15 kwh

PV P_{rated} = 150 Kwh

$Wind - turbine\ P_{rated} = 75kwh$

Micro-turbine P_{rated} = 15kw

The figure 5 below shows the convergence of the particle swarm optimization algorithm used in this study, the objective function described above takes the minimum value ≈ -99.5 $ for a



specific set of power output of the micro-turbine battery unit and utility. The optimization algorithm was run for 400

Fig. 4 distribution power requirement during the day

Generation (iteration) though as its obvious that the convergence succeeded on the first 5 iteration.

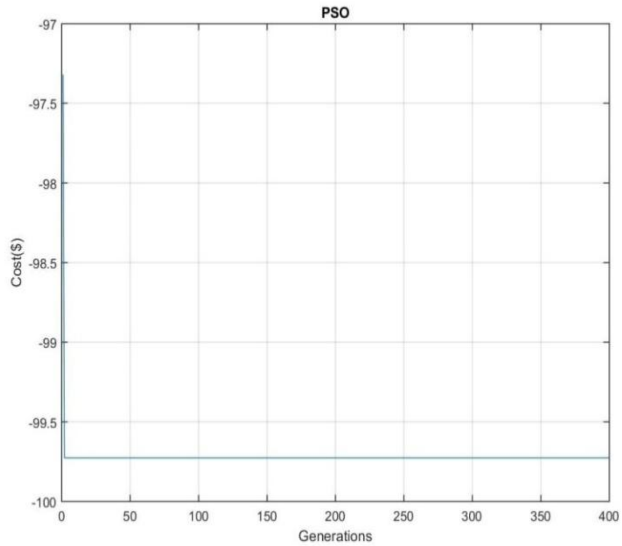


Fig. 5

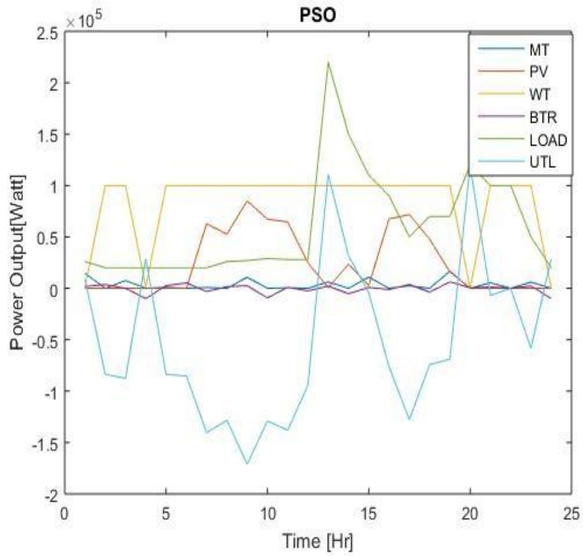


Fig. 6

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The set of power outputs which gives the minimum objective function are shown below. As for worth-noticed the maximum peak demand is between 10am to 15pm, which the load demand was increased. Here utility and WT aimed to cover the demands. Between 20pm and 22pm the load demand was increased. By this time renewable was not enough so the grid was obligated to buy again from the utility. Micro-grid bought enough power from the utility to cover load demand this two time interval as shown in fig. 6. As a result of reader can figure out the negative values of the objective. This condition was from utility to buying and selling.

$$\text{Battery } P_{\text{rated}} = 45\text{kwh}$$
$$\text{PV } P_{\text{rated}} = 225\text{kwh}$$
$$\text{Wind} - \text{turbine } P_{\text{rated}} = 225\text{kwh}$$
$$\text{Micro} - \text{turbine} P_{\text{rated}} = 60\text{kwh}$$

The difference from the previous one the output power is very high, battery and micro-turbine also high output power. The renewable sources PV and wind energy output is also greater. It is expected MG to able to cover the peak demand without buying from the utility. So the gain will be large compare to previous figure. 5. It's clear that look in fig. 7, the gain will be more was increased up to 300%.

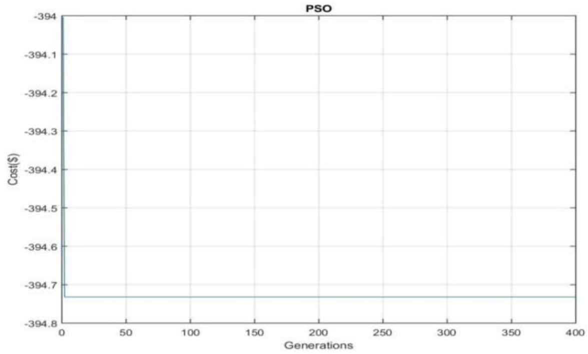

Fig. 7

Here the gain will be large because of RES and MT- battery output power is large so MG is able to cover the peak demand. The objective function described above takes minimum value ≈ 394.7$ specific set of power output MT, battery unit and utility.

If see as shown in figure 8 no need to buying from the utility. Because of here maximum output power in renewable PV and Wind energy. Here maximum peak load its covers the PV & wind energy system. This condition battery was charging if we have excess power. Really the MG need to buy a minor quantity of power from the utility just between 22:00-23:00

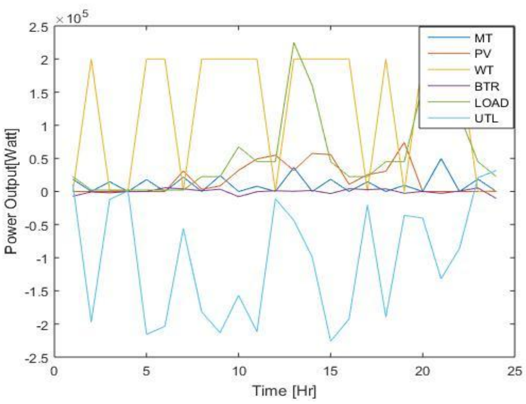

Fig. 8

Disconnected From the Utility

$$\text{Battery} P_{t,\text{rated}} = 15\text{kws}$$
$$\text{PV} P_{t,\text{rated}} = 150\text{kws}$$
$$\text{`Wind} - \text{turbine} P_{t,\text{rated}} = 75\text{kwh}$$
$$\text{Micro} - \text{turbine} P_{t,\text{rated}} = 15\text{kwh}$$

The general expectation is that the gain will be increased than the previous example. Buying from the utility is much more expensive than operating and maintaining a MT. Indeed it is obvious in figure 9, i. e. cost function is under the levels of the previous one details are shown in fig. 10, here disconnected to the utility here battery and micro turbine are minor output power, the maximum output power from PV& wind.

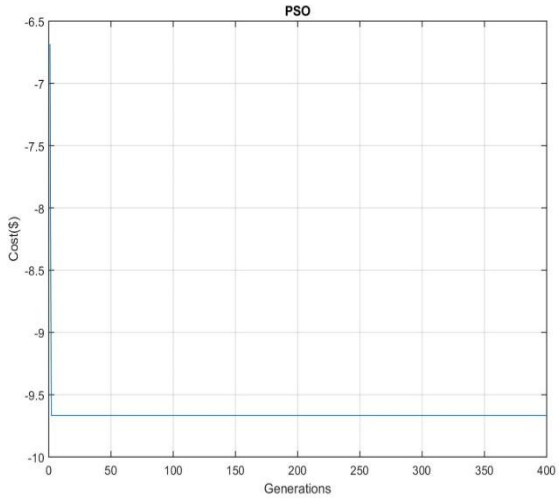

Fig. 9

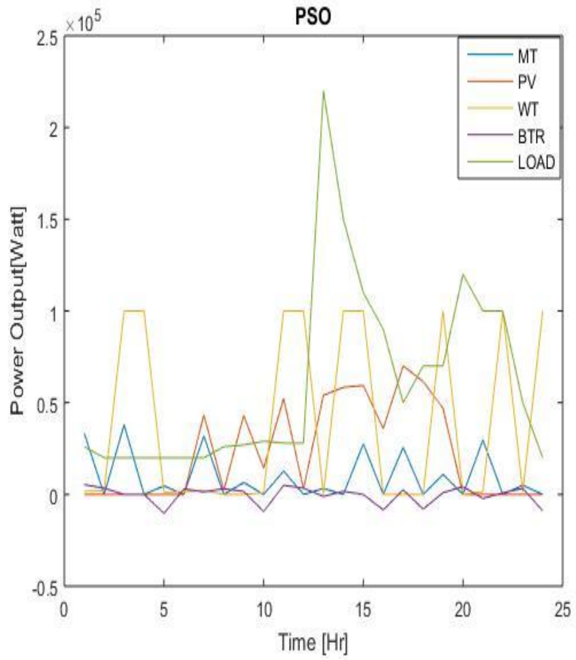

Fig. 10

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$$BatteryP_{t,rated} = 45kwh$$
$$PVP_{t,rated} = 225kwh$$
$$\text{Wind} - \text{turbineP}_{\text{t,rated}} = 225\text{kwh}$$
$$\text{Micro} - \text{tubine P}_{\text{rated}} = 45\text{kwh}$$

The casual expectation in figure 11 he gain will be increased too, due to power output of the supply units is increased compare to previous. However as in the previous example we can see in figure 12 the RES and storage unit never cover peak load demand at specific hour due to current conditions. Here MT aimed to serve the peak demand, as a result the cost increased a bit more than the previous one.

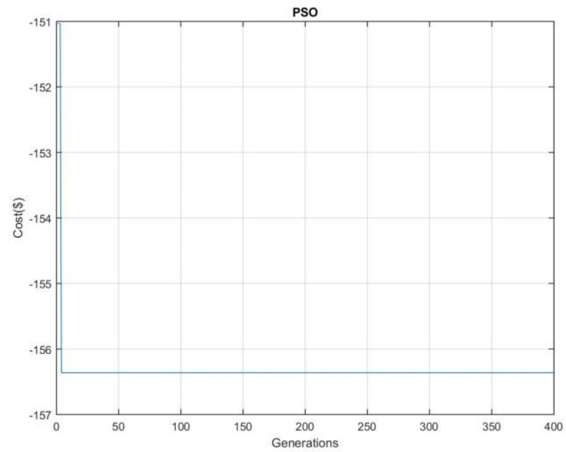

Fig. 11

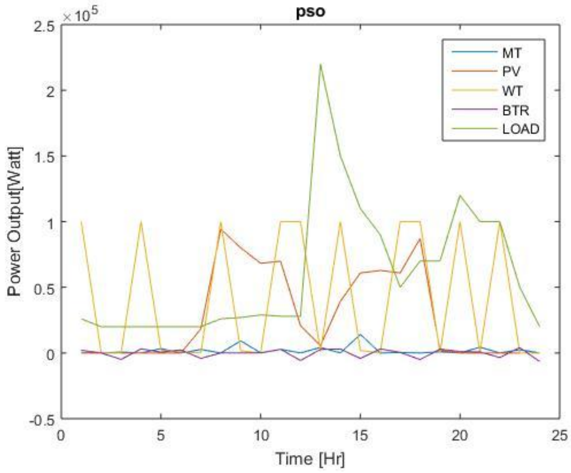

Fig. 12

V. CONCLUSION

Energy management by using renewable energy sources based on PSO mixture wind, photo voltaic, micro-turbine, energy storage bank and utility structurewas obtainable is present. Advanced energy management system helps energy stable in two customs initially by confirming an optimization energy balanceamong the involved generation resources built by several constraint, and next one including necessary management of renewable energy objective in to the energy management assessment making procedure. It planned to the particle swarm optimization (PSO) built optimization to become optimal power flow resolution for energy management constraints. Mostly solar energy wind energy sources are supported with storage battery. The constraints careful as the generation cost of the system exploit battery life checking and regulatory its (SOC) care/release. The specific chief merit of the optimization technique by founded EMS plan is fast conjunction period.

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