

# Optimal Design of a Hybrid Solar -Wind-Diesel Power System for Rural Electrification Using Imperialist Competitive Algorithm

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**Abstract-** In this paper, optimal design of a stand-alone hybrid solar- wind- diesel power generation system using Imperialist Competitive Algorithm, Particle swarm optimization and ant colony optimization is presented. The final goal of this paper is minimization of net present cost of hybrid system for lifetime of project ( here 20 years) considering by reliable supply of load and loss of power probability (LPSP) reliability index. In order to find out the least expenditure and best combination, the result of these algorithms compared together. Among these algorithms, the imperialist competitive algorithm is faster and more accurate than others and has more certain design in comparison to PSO and ACO algorithms. In this paper, first the mathematical model of various parts of hybrid system is presented. Then the purposed algorithm is used. Finally, simulation results ( number of PV panels, number of wind turbines, number of battery storages, system total cost ,power diagram of hybrid power system components and reliability diagram) for solar-wind -diesel systems is presented.

**Keywords-** Renewable energy, stand- alone power system, reliability, Imperialist competitive algorithm, optimization.

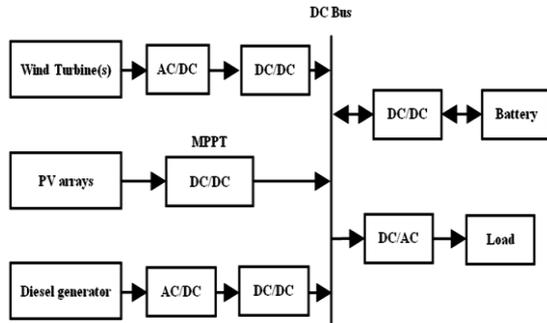
## 1. Introduction

In recent years, a considerable growth in using renewable energy resources has been observed. Specially, solar and wind energy are infinite, site-dependent, non-polluting, and high potential sources for alternative energy production. For remote systems such as radio telecommunications, satellite earth stations, or at sites far from a conventional power system, the hybrid energy systems is referable [1,2]. Such systems are usually equipped with diesel generators to meet the peak load demand during short periods, when the available energy is deficit [3]. Hybrid energy systems are best suited to reduce dependence on fossil fuel using available wind speed and solar radiations. A configuration of a hybrid energy system is shown in Fig. 1. It includes PV panels and/or wind turbines and/or diesel generator and/or batteries. These energy systems are considered as one of the cost effective solutions to meet

energy requirements of remote areas [4]. In [5] have developed the Hybrid Optimization by Genetic Algorithms (HOGA) program helping to determine the optimal configuration of the hybrid PV/diesel system. [6] presented a techno-economic analysis based on solar and wind biased months for an autonomous hybrid PV/wind energy system. He has observed that an optimum combination of the hybrid PV/wind energy system provides higher system performances than either of the single systems for the same system cost for a given battery storage capacity. He has also observed that the magnitude of the battery

storage capacity has an important bearing on the system performances of single photovoltaic and wind systems. [7] analyzed solar radiation data of Rafha, K.S.A., to assess the techno-economic feasibility of hybrid PV- diesel-battery over systems to meet the load requirements of a typical remote village Rawdhat Bin Habbas (RBH) with annual electrical energy demand of 15,943 MWh. HOMER software

has been used to perform the techno-economic evaluation. In [8], The optimal model of the solar system for a region of Turkey is done using the SA algorithm. [9] presents the analysis and design of a mixed integer linear mathematical programming model (time series) to determine the optimal operation and cost optimization for a hybrid energy generation system consisting of a photovoltaic array, biomass (fuel wood), biogas, small/micro-hydro, a battery bank and a fossil fuel generator for a remote rural of India.



**Fig. 1.** Schematic of a hybrid solar- wind- diesel power system[2]

The main goal of this paper is the size optimization of hybrid solar- wind- diesel power system regarding to the LPSP reliability index to provide reliable time with minimum cost using an evolutionary algorithm based on socio-political behaviour (ICA). In order to find out the least expenditure and best combination, the result of this algorithm compared by the PSO algorithm and ACO algorithm. Also the simulation results for solar-wind -diesel systems with reliability index are presented

**2. Mathematical model**

The models used in this paper for optimal design of hybrid systems is based on a sampled average daily weather data, which has been recorded by Ardabil meteorological organization. This data includes the ambient temperature, solar irradiation and wind speed [10].

**2.1. PV Array Modeling**

The output power from a PV panel can be calculated by an analytical model which defines the current-voltage relationships based on the electrical characteristics of the PV panel. This model includes the effects of radiation level and panel temperature on the output power. With a maximum power point tracker (MPPT), the output power from a PV panel is given as [10]:

$$P_{PV} = V_{mpp} \cdot I_{mpp} \tag{1}$$

$$V_{mpp} = V_{mpp,ref} + \mu_{V,OC}(T_C - T_{C,ref}) \tag{2}$$

$$I_{mpp} = I_{mpp,ref} + I_{SC,ref} (G_T / G_{ref}) + \mu_{I,SC}(T_C - T_{C,ref}) \tag{3}$$

where  $P_{PV}$  is the PV panel power (W) at the maximum power point at day t,  $V_{mpp}$  is the PV panel voltage at the maximum power point (V) at day t,  $V_{mpp,ref}$  is  $V_{mpp}$  at reference operating conditions (V),  $I_{mpp}$  is the PV panel current at the maximum power point (A) at day t,  $I_{mpp,ref}$  is  $I_{mpp}$  at reference operating conditions (A),  $I_{SC,ref}$  is the short circuit current at reference operating conditions (A),  $G_T$  is the daily irradiance on a tilted surface ( $W/m^2$ ),  $G_{ref}$  is the irradiance of  $1000W/m^2$  at reference operating conditions,  $\mu_{V,OC}$  and  $\mu_{I,SC}$  are the temperature coefficients for open circuit voltage ( $V/^\circ C$ ) and short circuit current ( $A/^\circ C$ ) respectively,  $T_{C,ref}$  is the PV panel temperature of  $25^\circ C$  at reference operating conditions and  $T_C$  corresponds to the PV panel operating temperature ( $^\circ C$ ) at day t and which can be expressed as follows [18] :

$$T_C(t) = T_a(t) + \frac{NOCT - 20}{800} \cdot G_T \tag{4}$$

where  $T_a$  is the ambient temperature ( $^\circ C$ ) of the site under consideration at hour t and NOCT (Normal Operating Cell Temperature) is defined as the cell temperature when the PV panel operates under  $800W/m^2$  of solar irradiation and  $20^\circ C$  of ambient temperature, NOCT is usually between  $42^\circ C$  and  $46^\circ C$  [19,2].

The PV panels are connected in series to form strings, where the number of panels to be connected in series  $N_{pv,s}$  is determined by the selected DC bus voltage ( $V_{bus}$ ) as follows [2]:

$$N_{PV,S} = \frac{V_{Bus}}{V_{pv,nom}} \tag{5}$$

Where  $V_{PV,nom}$  is the nominal PV panel voltage. Then  $N_{PV,s}$  is not subject to the optimization, whereas the number of parallel strings  $N_{pv,p}$  is the design variable that needs optimization.

**2.2. Wind Turbine Modeling**

The relationship between output from wind turbine and wind speed is as follows [11]:

$$P_{WT}(t) = \begin{cases} \frac{v - v_{ei}}{v_r - v_{eo}} P_R & V_{ei} < V < V_r \\ P_R & V_r < V < V_{ei} \\ 0 & other\ wise \end{cases} \tag{6}$$

Where V is sampling wind speed;  $v_{ei}$  is cut-in wind speed;  $v_{eo}$  is cut-out wind speed;  $v_r$  is rated wind speed;  $P_R$  is rated wind turbine power.[11] Using the wind speed at a reference height  $h_r(m)$  from the database, the velocity at a

specific hub height ( $h(m)$ ) for the location is estimated on an hourly basis throughout the specified period through the following expression.[2]

$$V(t) = V_r(t) \left( \frac{h}{h_r} \right)^\gamma \quad (7)$$

Fig. 2 shows typical wind turbine characteristics

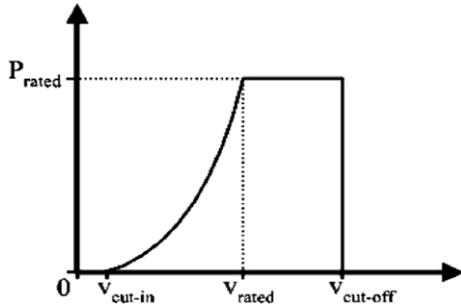


Fig. 2. Wind power versus wind speed.

### 2.3. Battery Bank modeling

For the charging process and discharging process of the battery bank, the state of charge (SOC) can be calculated from the following equation:

$$SOC(t + \Delta t) = SOC(t) + \eta_{bat} \left( \frac{P_B(t)}{V_{bus}} \right) \Delta t \quad (8)$$

where  $\eta_{bat}$  is equal to the round-trip efficiency in the charging process and is equal to the 100% in the discharging process [12],  $V_{bus}$  is the DC bus voltage (V) and  $\Delta t$  is the daily time step is set equal to 1day. For longevity of the battery bank, the maximum charging rate ( $SOC_{max}$ ) is given as the upper limit, it is equal to the total nominal capacity of the battery bank ( $C_n$  (Ah)) which is related to the total number of batteries ( $N_{bat}$ ), the number of batteries connected in series ( $N_{bat,s}$ ) and the nominal capacity of each battery ( $C_n$  (Ah)), as follows

$$C_n = \frac{V_{bat}}{N_{bat,s}} C_B \quad (9)$$

The lower limit that the state of charge of the battery bank cannot exceed at the time of discharging ( $SOC_{min}$ ) may be expressed as follows

$$SOC_{min} = (1 - DOD) \cdot SOC_{max} \quad (10)$$

The batteries are connected in series to give the desired

nominal DC operating voltage and are connected in parallel to yield a desired Ah system storage capacity. Then, the number of batteries connected in series depends on the DC bus voltage and the nominal voltage of each individual battery  $V_{bat,nom}$ , it is calculated as follows

$$N_{bat,s} = \frac{V_{bus}}{V_{bat,nom}} \quad (11)$$

The number of batteries to be connected in series is therefore not subject to the optimization but is a straightforward calculation, whereas the number of parallel battery strings, each consisting of  $N_{bat,s}$  batteries connected in series, is a design variable that needs optimization [2].

### 2.4. Power Reliability Model Based on LPSP Index

Because of the intermittent solar radiation and wind speed characteristics, which highly influence the resulting energy production, power reliability analysis has been considered as an important step in any system design process. A reliable electrical power system means a system has sufficient power to feed the load demand during a certain period or, in other words, has a small loss of power supply probability (LPSP). LPSP is defined as the probability that an insufficient power supply results when the hybrid system is unable to satisfy the load demand. It is a feasible measure of the system performance for an assumed or known load distribution. A LPSP of 0 means the load will always be satisfied; and an LPSP of 1 means that the load will never be satisfied. Loss of power supply probability (LPSP) is a statistical parameter; its calculation is not only focused on the abundant or bad resource period. Therefore, in a bad resource year, the system will suffer from a higher probability of losing power. There are two approaches for the application of LPSP in designing a stand-alone hybrid system. The first one is based on chronological simulation. This approach is computationally burdensome and requires the availability of data spanning a certain period of time. The second approach uses probabilistic techniques to incorporate the fluctuating nature of the resource and the load, thus eliminating the need for time-series data. Considering the energy accumulation effect of the battery, to present the system working conditions more precisely, the chronological method is employed in this research. The objective function, LPSP, from time 0 to T can then be described by

$$LPSP = \frac{\sum_{t=1}^T LPS(t)}{\sum_{t=1}^T P_{load}(t) \cdot \Delta t} \quad (12)$$

Where LPS(t) can be calculated as follow:

$$LPS(t) = P_{load} \cdot \Delta t - (P_p \cdot \Delta t + SOC(t-1) - (SOC_{min})) \eta_{inv} \quad (13)$$

Where  $\Delta t$  is the step of time used for the calculations (in this study  $\Delta t = 1$  Day). During that time, the power produced by the hybrid system are assumed constant. So, the power is numerically equal to the energy within this time step [13,14].

### 2.5. System Operation Strategies

The power generated by the hybrid system and the amount of energy stored are time dependent. So, the input/output power of the battery bank, is controlled by the following equation []:

$$\Delta P = P_{re}(i) - P_l(i) \quad (14)$$

Where

$$P_l(i) = \frac{P_{load}}{\eta_{inv}} \quad (15)$$

where  $P_{load}$  is the power demanded by the load and  $\eta_{inv}$  is the DC/AC converter efficiency specified by the manufacturer. Depending on the  $\Delta P$  value, the following cases apply:

If  $\Delta P > 0$ , the remaining power will be used to charge the batteries. If the batteries are completely charged, the exceed power is dumped.

If  $\Delta P < 0$ : the remaining power will be given by the batteries or by the diesel generator, depending on the dispatch strategy:

if the batteries are able to give  $\Delta P$ , then: batteries discharge and diesel generator turns off

$$P_b(i) = \Delta P \quad (16)$$

if the batteries are not able to give  $\Delta P$ , the diesel generator turns on, and the batteries will neither be charged nor discharged. Then the diesel generator output power  $P_d(i)$  is expressed as follows

$$P_d(i) = \Delta P \quad (17)$$

The flowchart of this strategies shown in figure (3).

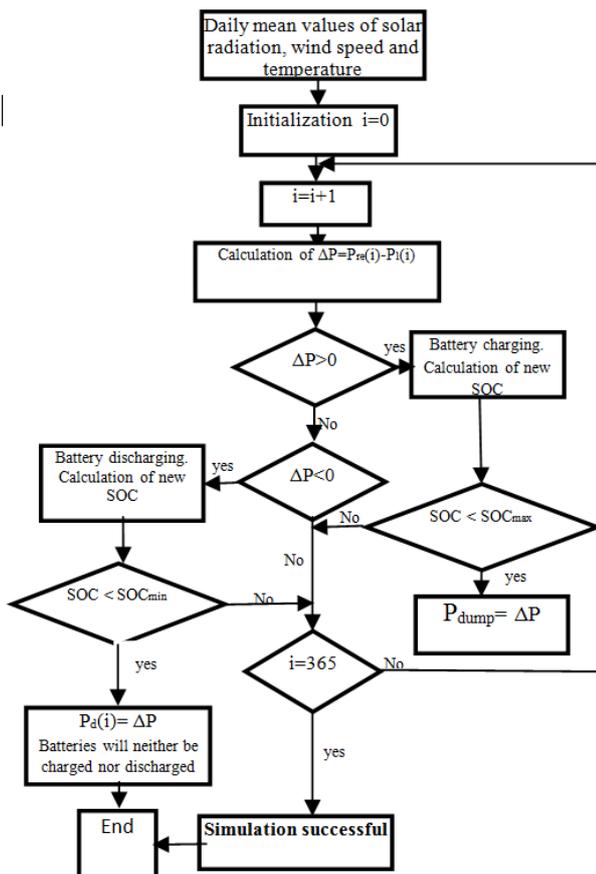


Fig. 3. The flowchart of system operation strategies

### 3. Size Optimization Algorithm

#### 3.1. Imperialist Competitive Algorithm

Optimal sizing algorithm the proposed algorithm starts with an initial population (countries in the world). Some of the best countries in the population are selected to be the imperialists and the rest form the colonies of these imperialists. All the colonies of initial population are divided among the mentioned imperialists based on their power. The power of an empire which is the counterpart of the fitness value in GA, is inversely proportional to its cost. After dividing all colonies among imperialists, these colonies start moving toward their relevant imperialist country. The total power of an empire depends on both the power of the imperialist country and the power of its colonies. We will model this fact by defining the total power of an empire by the power of imperialist country plus a percentage of mean power of its colonies. Then the imperialistic competition begins among all the empires. Any empire that is not able to succeed in this competition and can't increase its power (or at least prevent decreasing its power) will be eliminated from the competition. The imperialistic competition will gradually result in an increase in the power of powerful empires and a decrease in the power of weaker ones. Weak empires will lose their power and ultimately they will collapse. The movement of colonies toward their relevant imperialists along with competition among empires and also the collapse mechanism will hopefully cause all the countries to converge to a state in which there exist just one empire in the world and all the other countries are colonies of that empire. In this ideal new world colonies, have the same position and power as the imperialist [15].

#### 3.2. Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a relatively novel approach for global stochastic optimization. It simulates a swarm, or flock, of beings wandering in the parameter space and is based on a "social interaction" metaphor in which the path of the beings in the parameter space is controlled according to a swarm- or flock-like set of rules [22].

#### 3.3. Ant Colony Optimization

Ant colony algorithms are based on the behavior of social insects with an exceptional ability to find the shortest paths from the nest to the food sources using a chemical substance called pheromone. [23].

### 4. Objective Function and Constraints

The Annualized Cost (AC) of component  $i$  is defined as [16]:

$$AC(x) = N \times \{ [CC + RC \times K(ir, L, y)] \times CRF(ir, R) + C_M \} \quad (18)$$

where, N may be number (unit) or capacity (kW or kg), CC is capital cost (\$/unit), RC is cost of each replacement (\$/unit), and O&MC is annual operation and maintenance cost (\$/unit-yr) of the component, and R is the useful lifetime of the project (here, 20 years).  $i_r$  is the real interest rate (here, 6%) which is a function of nominal interest rate ( $i_{nominal}$ ) and annual inflation rate ( $f_r$ ), defined by

$$i_r = \frac{(i_{r,nominal} - f_r)}{1 + f_r} \quad (19)$$

Iso, CRF and K are capital recovery factor and single payment present worth [20], respectively, which are defined as follows:

$$CRF(i_r, R) = \frac{(1 + i_r)^R - 1}{(1 + i_r)^R i_r} \quad (20)$$

$$K(i_r, L, y) = \sum_{n=1}^y \frac{1}{(1 + i_r)^{n \times L}} \quad (21)$$

where, L and y are useful lifetime and number of replacements of the component during useful lifetime of the project, respectively. Number of replacements of each component is a simple function of useful lifetimes of the component and the project [16].

The following equation shows the fuel consumption cost for 1 h of running of the diesel generator [2]

$$C_{fuel} = Pr_{fuel} \cdot (A.P_D + B.P_{RD}) \quad (22)$$

where  $Pr_{fuel}$  is the fuel price (\$/l),  $A = 0.246$  l/kW and  $B = 0.0845$  l/kW are the fuel curve coefficients.

The minimization of the objective function is subject to the constraints that the power produced by the system is larger than to the power demanded by the load and the state of charge of the battery bank is limited between  $SOC_{min}$  and  $SOC_{max}$  and LPSP is limited between  $LPSP_{min}$  and  $LPSP_{max}$  as follows

$$\begin{cases} P_p \geq P_l \\ SOC_{min} \leq SOC \leq SOC_{max} \\ LPSP_{min} \leq LPSP \leq LPSP_{max} \end{cases} \quad (23)$$

where PP is the power produced by the system, it is calculated as follows

$$P_p = P_{RE} + P_D - P_b \quad (24)$$

where PRE is the power produced by the renewable resources as follows

$$P_{RE} = N_{PV} \cdot P_{mpp} + N_{WT} \cdot P_{WT} \quad (25)$$

$P_{mpp}$  and  $P_{WT}$  are respectively the power at the maximum power point of the PV panel (W) and the output power of the wind turbine (W),  $N_{PV}$  and  $N_{WT}$  are respectively the total number of PV panel and wind turbine and

$N_{PV} = N_{PV,P} \times N_{PV,S}$  is the total number of PV panels and  $N_{WT}$  is the total number of wind turbines.

PB is the input/ output power of the battery bank,  $P_b > 0$  during the charging process of the battery and  $P_b < 0$  in the discharging process [2]

Then, the model of the sizing optimization of the standalone hybrid PV-Wind-diesel system is expressed as follows

$$\text{Min STC}(x) = \text{minx} \{ AC(x) + C_{fuel} \} \quad (26)$$

$$\text{where } x = \{ N_{PV,P}, N_{WT}, N_{Bat,P} \} \quad (27)$$

$$P_p(t) \geq P_L(t) \quad (28)$$

$$SOC_{min}(t) \leq SOC(t) \leq SOC_{max}(t) \quad (29)$$

$$LPSP_{min} \leq LPSP \leq LPSP_{max} \quad (30)$$

$$0 \leq N_{PV,P} \leq N_{PV,Pmax} \quad (31)$$

$$0 \leq N_{WT} \leq N_{WTmax} \quad (32)$$

$$0 \leq N_{Bat,P} \leq N_{Bat,Pmax} \quad (33)$$

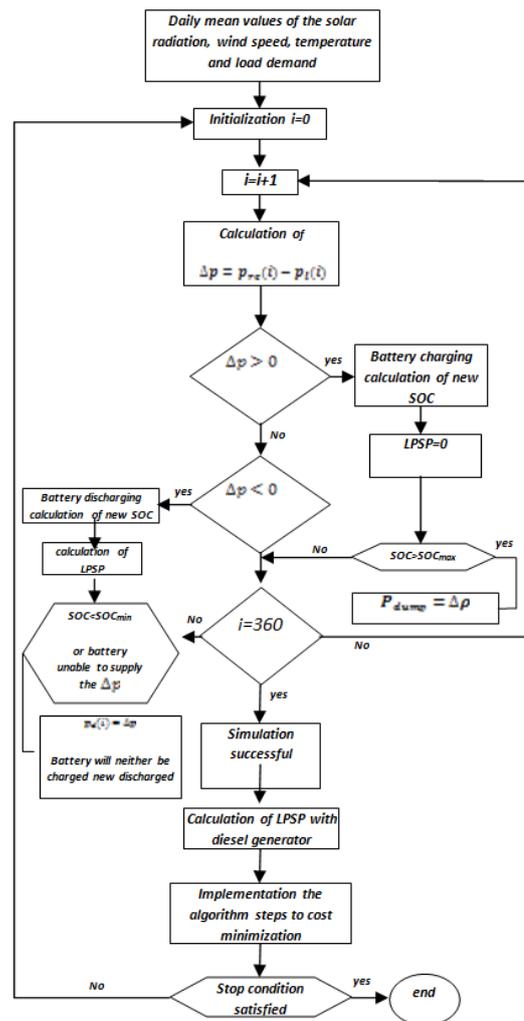


Fig. 4. The flowchart for designing proposed hybrid system

The goal of optimization is to find an optimal solution in terms of the variables of the problem. The algorithm form an array of variable values to be optimized. In ACO terminology, this array is called "ant", In PSO terminology is called "particle" but here the term "country" is used for this array. In a  $N_{var}$ - dimensional (in this paper  $N_{var} = 4$ ) optimization problem, a country is a  $1 \times N_{var}$  array. this array is defined by

$$Country = [N_{PV}; N_{WT}; N_{bat}; N_{inv}] \quad (34)$$

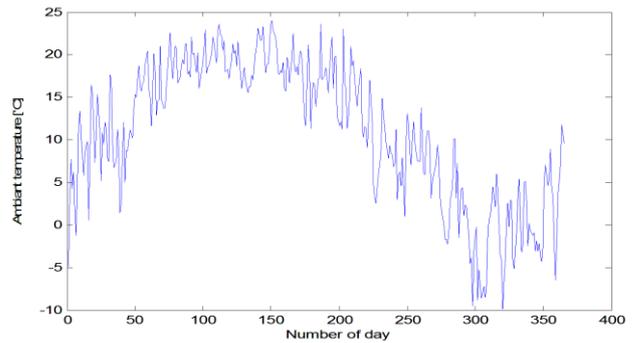
The variable values in the country are represented as floating point numbers. The cost of a country is found by evaluating the cost function  $f$  at the variables ( $N_{PV}, N_{WT}, N_{bat}, N_{inv}$ ).then

$$Cost = f(country) = f(N_{PV}; N_{WT}; N_{bat}; N_{inv}) \quad (35)$$

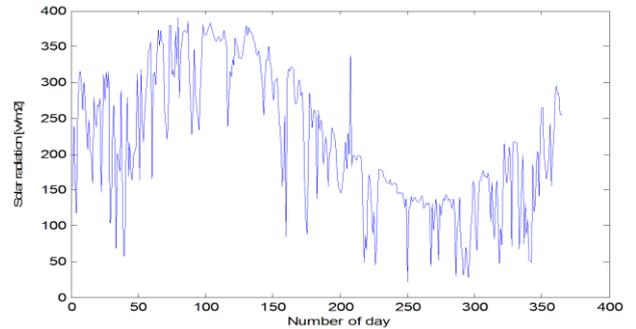
To start the optimization algorithm the initial population of size  $N_{pop}$  (here  $N_{pop} = 30$ ) is generate. Then select  $N_{imp}$  of most powerful countries to form the empires. The remaining  $N_{col}$  of the population will be the colonies each of which belongs to an empire. The formation of the  $N_{imp}$  and  $N_{col}$  is explained completely in [15].Then for each initial population (in this algorithm countries) operation strategy is checked for the overall performance during the year. Populations that able to supply the load selected by the algorithm. The algorithm continues to find the best combination by minimum cost and compliance with the relevant Constraints of the objective function is carried out. This process is done until the number of iterations for the algorithm to be finished and it is shown in figure (4). Finally the best system with the minimum cost is obtained. In this paper outputs are the optimum number of the components of hybrid system ensuring that the system total cost is minimized subject to the constraint that the load demand is completely supplied. In this paper, number of population ( $N_{pop}$  for the ICA) is set to 30 and the number of iterations (decades for the ICA) is set to 100.

**5. Results and Discussion**

The proposed method was used for design a hybrid system to provide variable power (15 kw peak load) for a region of northwest of Iran (in Ardebil province). 12-month series of wind speed, solar radiation and ambient temperature in daily average form which recorded by the meteorological organization and shown in Figures 4 to 7 [21].

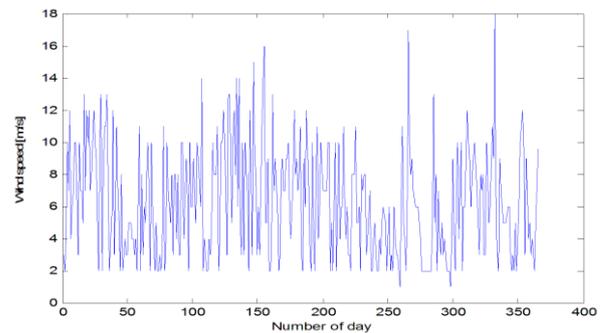


**Fig. 5.** Daily mean values of ambient temperature



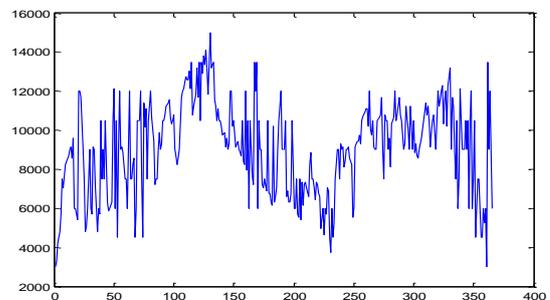
**Fig. 6.** Daily mean values of solar irradiation

Wind speed measured at a height of 40 meters and has been shown in the figure 4.



**Fig. 7.** Daily mean values of wind speed

Daily distribution of power demand for a year is shown in Figure(8)



**Fig. 8.** Daily mean values of demanded power during a year

A diesel generator has been used in this application, has a rated power of 15 kW. The system components

characteristics and initial investment, maintenance and installation costs, are listed in Table 1 to 3 [2].

**Table 1.** PV panels specifications

$V_{oc}(V)$	33.2
$I_{sc}(A)$	8.85
$V_{max}(V)$	26.6
$I_{max}(A)$	7.9
NCOT(oC)	47.9
Capital cost(\$/kw)	400
Replacement cost(\$)	400
Maintenance cost (\$/year)	4

**Table 2.** Wind turbine specifications

Rated power (KW)	5
$v_r$ (m/s)	11
$v_{ci}$ (m/s)	2.5
$v_{co}$ (m/s)	24
Capital cost(\$)	7500
Replacement cost(\$)	7500
Maintenance cost (\$/year)	75

**Table 3.** Battery specifications

Nominal capacity (Ah)	230
Voltage (v)	12
DOD (%)	80
Efficiency (%)	85
Capital cost(\$)	225
Replacement cost(\$)	225
Maintenance cost (\$/year)	2

The PV panel lifetime is 20 years. The diesel generator lifetime is 15000 h. The fuel price is 0.9 \$/l. The capital cost and the maintenance cost of the diesel generator are respectively 3000 \$ and 3 \$/h .

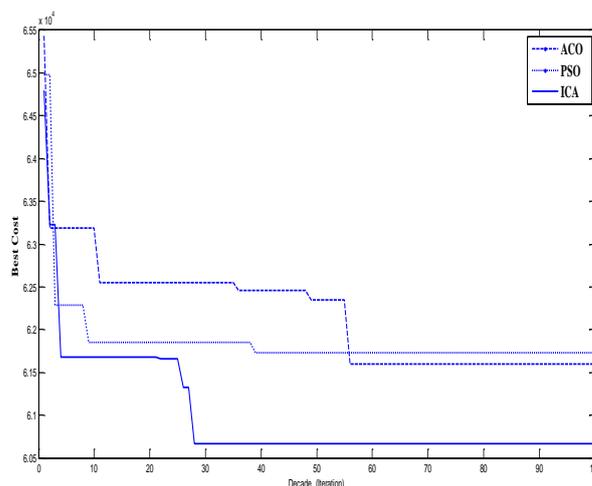
The DC bus voltage is chosen to be equal to 48 V. Hence, the number of PV panels and batteries connected in series are determined by fulfilling the DC bus voltage. The expected battery lifetime has been set to 3 years with proper maintenance, then  $Y_{bat} = 6$  resulted.

Results of the optimal design of hybrid systems with the overall system costs are shown in Table 4.

**Table 4.** Optimal results of different hybrid system

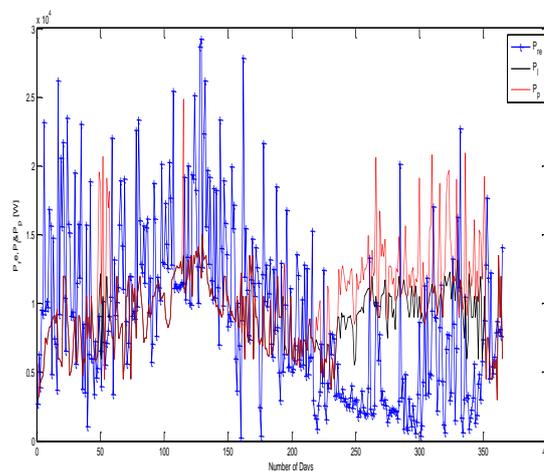
Optimization algorithm	ICA	ACO	PSO
optimal results			
$N_{PV}$	31	34	34
$N_{WT}$	4	4	4
$N_{Bat}$	16	15	15
$N_{inv}$	10	8	8
Total cost (\$)	60670	61600	61730

Finally the cost of various combinations with diesel generator has been shown in Figure 6 :

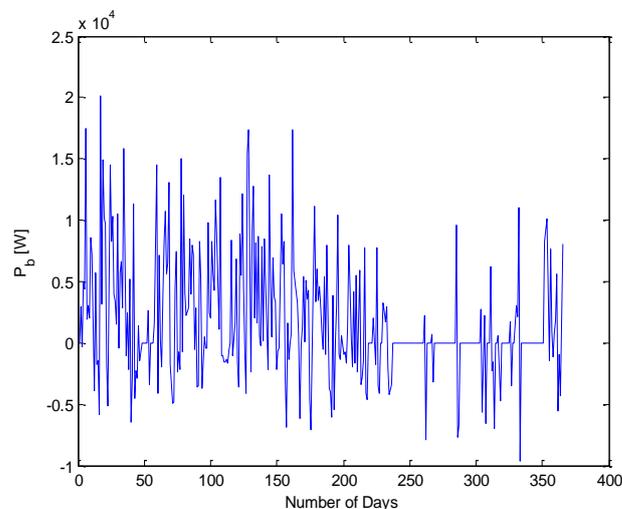


**Fig. 9.** Convergence of optimization algorithms

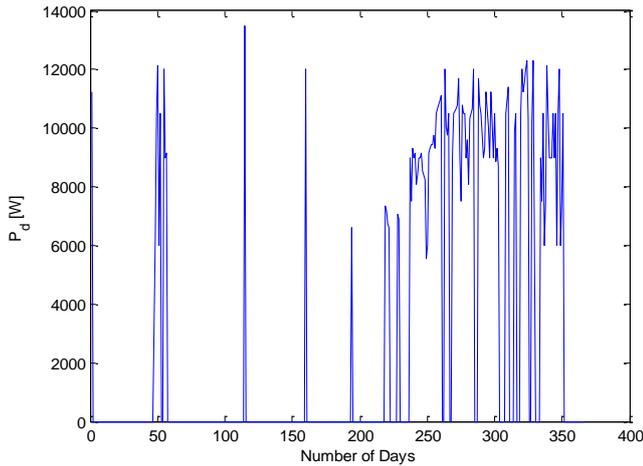
According to Figure (9) and Table (4), the ICA algorithm is faster and more accurate than other algorithms and has more certain design in comparison to PSO and ACO algorithms.



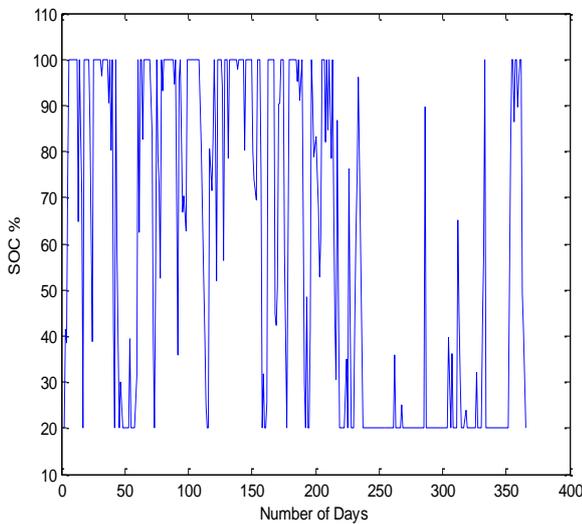
**Fig 10.** Hybrid system power( $P_p$ ), renewable sources power( $P_{re}$ ) and load demand ( $P_l$ )



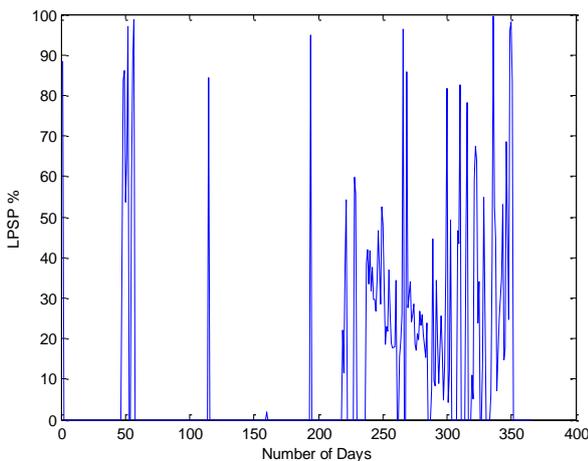
**Fig. 11.** Input/output of battery bank during a year



**Fig. 12.** Diesel generator power during a year



**Fig. 13.** State of charge of battery bank



**Fig. 14.** Hybrid system reliability index (LPSP)

Figures (9) to (13) represent the share of renewable sources, diesel generator and battery supply for reliable

power providing. Also, the batteries SOC and system LPSP in hybrid system is shown.

Figure (9) , shows the power produced by renewable sources ( $P_{re}$ ), the total power produced by the hybrid system ( $P_p$ ) and the demand power load solar - wind – diesel system. Figure (11), represents the input/ output power of the battery bank and determine how to charge and discharge them over the years for the solar - wind – diesel system.  $P_b > 0$  is indicates the battery charging and the input power and  $P_b < 0$  represents the battery discharging and output battery power. Figure (12), are show the diesel usage over the year. In this design the diesel generator will supply the load, when the renewable sources and the battery banks can't supply the load. According to figure it is noted that the diesel generator does not work with the rated power. Its maximum output power in the hybrid systems is 13 KW, which operated 1 days per year for hybrid solar- wind -diesel systems. Also, for 256 days the diesel generator is off which represents the fuel saving. Figure (13) shows that the state of charge of the battery bank never exceeds the permissible maximum value of  $SOC_{max}$  (100% of SOC), and never be below the permissible minimum value of  $SOC_{min}$  (20% of SOC). Figure (14) illustrate the reliability index (LPSP) of the hybrid system during the year. If  $LPSP = 0$ , the designed system will be reliable supply the load, and if  $LPSP = 1$ , the designed system, will not be able to supply the load. From the above figures concluded that, the 15 kW load, with system can be fully supported. In each time, the batteries and the renewable resources are unable to supply the load, the diesel generator turns on and provides the load.

**6. Conclusion**

In this paper the optimal design of a stand-alone hybrid system using Imperialist Competitive Algorithm, Particle swarm optimization and ant colony optimization is presented. This design, was implemented considering the reliable load providing and the LPSP reliability index, for wind- solar- diesel system. The results show that the Imperialist Competitive Algorithm is faster and more accurate than other algorithms and has more certain design in comparison to PSO and ACO algorithms. The costs were obtained for Imperialist Competitive Algorithm, Particle Swarm Optimization and Ant Colony optimization are 60670 \$, 61730 \$ and 61600 \$, respectively. The reliability index for the optimal combination of these systems are 3.7%, 4.4% and 4.1%, respectively which these indices are in the normal range. The cost of fuel consumption using the hybrid solar - wind- diesel system, is 34700 \$/yr, while in the diesel system is 7282.8 \$/yr. Finally, the cost saving in fuel consumption using the hybrid.

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