American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-08, pp-234-242
www.ajer.org

Research Paper Open Access

Using A Battery Storage Wind / PV Hybrid Power Supply System Based Stand-Alone PSO To Determine The Most Appropriate.

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ABSTRACT : Wind / PV hybrid power systems, completed in time and geography, both economical and reliable than PV or wind turbine, but the hybrid system wind / PV to increase capacity. Installation of experience with traditional power design and optimization of design and operation cannot be seen with. To solve the problem in a comprehensive objective function to present the objective function of the solar wind. And reliability of the storage cells can be calculated with an investment of erosion format system resources, including the number of solar cells and batteries, but the type and amount of solar wind to change. As well as to improve not only to make the results more accurate investment costs and reliability cost of conversion optimization problems several optimization problems today.Improved optimization algorithms, PSO are used to solve nonlinear hybrid analysis is any integer optimization problem on the basis of PSO algorithm standard techniques then there is the first step convergence factor is applied to improve the detection performance of both migration are used to improve the ability of the algorithm to find the best in the whole world**.**

I. INTRODUCTION

In recent years, many new renewable energy technologies are into commercial applications, the maximum possible and the fastest growing wind and solar power. Low efficiency and poor reliability of wind and solar power, however, although the study of solar and wind energy, time and geography found in. Complete two very small wind most of the day in the sun when the wind began to strengthen. Because there are significant changes in the surface temperature of the light is very weak cold summer, sunshine, windy and weak winter sunlight is reduced and windy, so the best match for energy assets. Solar energy storage system and a full wind, wind / solar wind is provided by renewable solar electricity / assembly and storage. Material security, both in terms of the cost of solar or wind power to generate more profitable.Wind / diesel power system components and how the various components of the system to match the key advantages to the full game systems, hybrid power, and the optimization of the composition of the linearity of the power plant itself. Itself and the complexity of the linear system; Creating Nonlinear optimization problem some wind / current power systems research alone hybrid solar to supplement their education with some valuable advice on optimization problems that will be sent, but it is unclear as well the failure of some of the problems that continue in spite of the tendency of the PV cell system reliability and find out how best to deal with the hassles and inefficiencies. To solve this problem based on Optimization of this project is to improve the PSO algorithm proposed in this calculation model was established on a project to simulate the actual operation of the system can work not only with modern facilities , including the advantages of PSO and genetic algorithms . Fix the PSO algorithm, the global convergence properties of both higher capacity and efficiency. Quick search is in this article, the validity of the proposed method is tested with classical test cases.

II. PROBLEM FORMULATION

Typically, wind / solar renewable energy systems, wind turbines, solar panels, solar panels listed in the battery drain voltage control devices and other components of the cost of the first studies that follow this system.

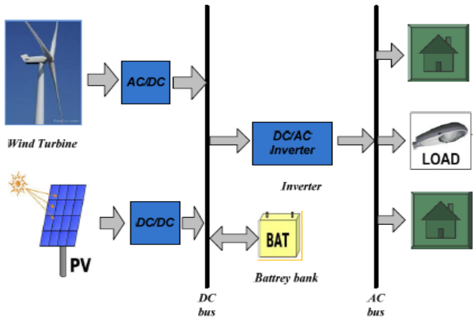

Fig. 1. Block diagram of a hybrid system.

Wind turbine output model : Wind turbine output characteristic curve shown in Figure 2. So the wind turbine output characteristic equation that can be exported by using the curve fit.

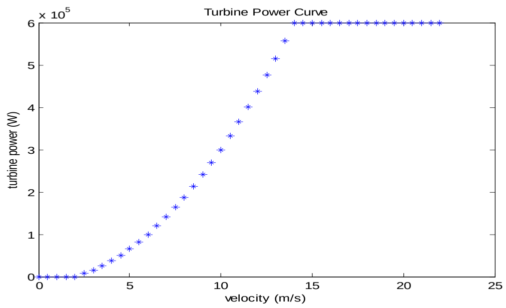

Fig.2 The output of wind turbines

The output characteristics equation of wind turbine is given as below:

$$Pwt = \begin{cases} 0, & V_W \le V_C, V_W \ge V_f \\ P_R \times \dfrac{V_W^2 - V_C^2}{V_R^2 - V_C^2}, & V_C \le V_W \le V_R \\ P_R, & V_C \le V_W \le V_R \end{cases}$$

Where,
P_{WG}: The wind turbine output power (Watt)
P_R: The wind turbine rated power (Watt)
V_W: The wind speed (m/s)
V_C, V_F, V_R: Cut-in, cut-out and rated or nominal speed of the wind turbine (m/s)

PV cells output model : Turn on solar photovoltaic installed capacity is an important factor. The decision to change the PV array, which will be the highest yield, but this can cause one of the solar power system, in fact, solar power generation system. By turning the power output of the turbine, and other issues related to the design changes were put into operation as a decision variable in PV cells (PPV (T)) and replacement (ϴ) a. the relationship between the output powers as a function of the model can be written as a singer.

PPV (t) f (VM (θ) I (θ)) = (2).

I vm respectively, the voltage and current is from the solar cell.

The battery output model : Because, the output is the random behavior of solar cells and wind turbines, the capacity of the battery is a hybrid of the changes to the system. Turbines and solar cells are larger than the total amount of electrical load and battery charge state of the battery on the T (3) can be expressed as:

$$Pb(t) = Pb(t-1).(1-\sigma) + \left[Pz(t) - \frac{Pl(t)}{\eta inv}\right].\eta bc \qquad (3)$$

Where,

Pb(t): Battery charged quantity at time (*t*);

Pb(t-1): Battery charged quantity at time (*t*-1)*;*
σ: Battery self-discharge rate per hour;
Pz(t): The total output power of the turbine and PV cells in the time interval (*t* -1) -(*t) ;*
Pl(t): The total load power in the time interval (*t* -1) -(*t);*
ηinv: Inverter efficiency;
ηbc: Battery charging efficiency;
ηbf : Battery discharging efficiency;

The reliability model : The reliability is an important indicator in evaluating a power generation system, which measures in terms of loss of power supply probability (LPSP). The LPSP for a considered period T is defined by:

$$LPSP = \sum_{t=1}^{T} LSP(t) / \sum_{t=1}^{T} Pl(t) \qquad (5)$$

The LPSP for the time t is obtained through (6):

$$LPS(t) = [Pl(t) - (Pz(t) + Pb(t-t) - Pbmin).\eta inv].u(t) \qquad (6)$$

Where, T is the running time considered, here T =8760 hours; Pl(t) The total load power in the time interval (t -1) -(t); Pz(t) The total output power of turbines and PV cells in the time interval (t-1) - (t); Pb(t-1) Battery charged quantity at time (t-1); Pbmin the minimum charged quantity of battery ; ηinv is Inverter efficiency; u(t) is a step function[5];

III. RESEARCH

A. The objective function

The objective function is the total annual cost of system, which consists of the cost of various components in the system and the annual cost of power loss. It can be obtained in (7):

minCz = min(Cw + Cpv + Cb + Cr) (7)

Where,
Cz The total annual cost of components in the system;
Cw The total cost of wind turbines;
Cpv The total cost of PV panel;
Cb The total cost of the batteries;
Cr The total annual cost of power loss of system.

1) The total cost of wind turbines

$$C_w = \sum_{i=1}^{W_n} (a_i N_i \cdot \frac{r_0(1+r_0)^m}{(1+r_0)^m - 1} + u(N_i)) \qquad (8)$$

$$u(P_i) = \frac{r_0(1+r_0)^m}{(1+r_0)^m - 1} [\sum_{t=t'}^{n} a_i N_i (1+r_0)^{n-t} + \sum_{t=n+1}^{m} a_i N_i \cdot \frac{1}{(1+r_0)^{t-n}}] \qquad (9)$$

2) The total cost of PV cells

$$C_{pv} = \sum_{j=1}^{S_n} (b_j N_j \cdot \frac{r_0(1+r_0)^m}{(1+r_0)^m - 1} + u(N_j)) \qquad (10)$$

$$u(P_j) = \frac{r_0(1+r_0)^m}{(1+r_0)^m - 1} [\sum_{t=t'}^{n} b_j N_j (1+r_0)^{n-t} + \sum_{t=n+1}^{m} b_j N_j \cdot \frac{1}{(1+r_0)^{t-n}}] \qquad (11)$$

3) The total cost of batteries

$$C_b = \sum_{k=1}^{B_n} (c_k N_k \cdot \frac{r_0(1+r_0)^m}{(1+r_0)^m - 1} + u(N_k)) \qquad (12)$$

$$u(P_k)=\frac{r_0(1+r_0)^m}{(1+r_0)^m-1}\left[\sum_{t=t'}^{n} c_k N_k (1+r_0)^{n-t} + \sum_{t=n+1}^{m} c_k N_k \cdot \frac{1}{(1+r_0)^{t-n}}\right] \quad (13)$$

Where, *Wn, Sn, Bn* are respectively the style of the turbines, PV cells and batteries; a_i, b_j, c_k are respectively the unit cost of the turbine, PV cells, and battery for the type of *i, j, k;* P_i, P_j, P_k are capacity of the turbine, PV cells, and battery for the type of *i, j, k* respectively; $u(P_i)$, $u(P_j)$, $u(P_k)$ are the annual maintenance and operation costs of the turbine, PV cells, and battery with capacity of P_i, P_j, P_k for the type of *i, j, k* respectively; *n* is the period of the installation and construction of equipments; *t'* is the starting age of equipments put into operation; *m* is depreciable lifetime of equipment; r_0 is discount rate; and *t* is the year.

4) The total cost of power loss of system considering supply reliability

$$Cr = coe \times \sum_{t=1}^{T} LPS(t) \quad (14)$$

Where, *coe* means compensation coefficient, from (14) it can seen that if *coe* is improved, the cost of power loss of system will be increasing. In order to avoid the cost of power loss is too large, hybrid generating system has to reconfigure the various components and to lower loss of power supply probability (LPSP), thereby the reliability can be controlled by controlling *coe.*

B. Decision variables

From the above analysis, operational decision variables include the following variables:

$$X = \{Sn, Npv.p, \theta, Wn, N_{WT}, Bn, N_{BAT.P}\} \quad (15)$$

Where, *Wn, Sn, Bn* are respectively the style of the turbines, PV cells and batteries; *Npv.p*, N_{WT}, $N_{BAT.P}$ are respectively the number of turbines, PV cells and batteries; θ is the inclination of PV cells.

C. Constraints

1) The constraints of the inclination of PV cells:

$$0< \theta<90^0 \quad (16)$$

2) The constraints of the number of turbines, PV cells and batteries;

$$0 \le Npv,p \le Npv,pmax$$
$$0 \le N_{WT} \le N_{WTmax} \quad (17)$$
$$0 \le N_{BAT,P} \le N_{BAT,Pmax}$$

Where $N_{pv,Pmax}$, N_{WTmax}, $N_{BAT,Pmax}$ are respectively the maximum allowable number of the installation of turbines, PV cells and batteries.

3) The constraints of the capacity of batteries;

$$P_{bmin} \le P_{b(t)} \le P_{bmax} \quad (18)$$

Where, P_{bmax} means the maximum allowable capacity of batteries, which is generally set to rated battery capacity P_{bc} ; P_{bmin} means the minimum allowable battery capacity, which is determined by the maximum depth of discharging DOD , that is P_{bmin} =(1-DOD).P_{bc}, and DOD is generally set to 30%~50%.

IV. IMPROVED PSO ALGORITHM

A. PSO algorithm

Particle Swarm Optimization (PSO) was first proposed by J. Kennedy and R.C. Eberhart in 1995. The algorithm began as a simulation of the predatory behavior of birds flocking, in which each agent, according to its own flying experience and that of its neighbors, constantly modifies its flight direction and velocity, and ultimately approaches to the global best position through the whole searching space. In PSO algorithm the particle of *i* can be expressed by a D-dimensional vector and the position vector $x_i = (x_{i1},x_{i2},\ldots,x_{iD})^T$, the velocity vector $v_i = (v_{i1},v_{i2},\ldots,v_{iD})^T$

The particle swarm optimizer adjusts velocities and positions by the following formula:

$$v_{id}^{k+1} = v_{id}^{k} + c_1 r_1 \left(P_{best,id}^{k} - x_{id}^{k}\right) + c_2 r_2 \left(g_{best,d}^{k} - x_{id}^{k}\right) \quad (19)$$

$$x_{id}^{k+1} = x_{id}^{k} + v_{id}^{k+1} \quad (20)$$

Where,

v_{id}^{k} current d-dimensional velocity of agent *i* at iteration *k* ,

c_1, c_1 acceleration factor(known as study operator) , respectively adjusts the largest step length of flying direction to the g_{best} and the p_{best} , generally $c_1 = c_2 = 2.0$;

x_{id}^{k} current d-dimensional position of agent t *i* at iteration *k* ;

$P_{best,id}^{k}$ D-dimensional p_{best} of agent t *i* at iteration *k* ;

$g_{best,id}^{k}$ D-dimensional g_{best} of the group ;

B. The improved form of PSO algorithm

1) The introduction of a confluence of factors.

The movement of the particles (21) can be updated accordingly, in order to accelerate the rate of convergence, the convergence factor of the PSO algorithm is introduced [4], which has been developed in the literature.

$$v_{id}^{k+1} = K[v_{id}^{k} + c_1 r_1 (P_{best,id}^{k} - x_{id}^{k}) + c_2 r_2 (g_{best,d}^{k} - x_{id}^{k})] \qquad (21)$$

Where, *K* is a function of c_1 ,c_2 as reflected in equation (22)

$$K = 2 / \left|2 - \varphi - \sqrt{\varphi^2 - 4\varphi}\right|, \varphi = c_1 + c_2, \varphi > 4 \qquad (22)$$

Generally, $\varphi = 4.1, c_1 = c_2 = 2.05$. Different types of functions are tested and the result showed that the PSO algorithm which has been introduced the convergence factor is superior to the standard PSO algorithm in improving the convergence speed.

2) Migration and mutation.

Standard PSO algorithm, it is easy to read because the competition is one of the best local, more particles to improve the global search. Transition Genetic algorithms have been introduced in the paper this idea, mutations to expand the optimization of overlapping particles and fitness monitoring the parent mass used overlap.

Definition: Let the particle's number *n*, f_i is the fitness of the *i*th particle, f_{av} is the average fitness at present, f_{best} is the best fitness of particles, σ^2 is the fitness variance of particles, then σ^2 can be defined as below:

$$\sigma^2 = \sum_{i=1}^{n} [(f_i - f_{av}) / f_{best}]^2 \qquad (23)$$

This definition shows that the fitness variance of particles σ^2 reflects the extent of "converge" of particles, the smaller σ^2 is, the higher the degree of aggregation of particles is; conversely, the more dispersed the distribution of individual of particles is. In the process of the mutation of particle swarms, the mutation probability should be dynamic, and the selection of the mutation probability should be related to overlapping condition of the swarms. It can be seen from (23) that the fitness variance is in the range between 0 and n .Therefore, the mutation probability is obtained by (24):

$$p_m^k = p_{\min} + (p_{\max} - p_{\min})(1 - \sigma_k^2 / n) \qquad (24)$$

Where, P_m^k mutation probability of the swarms at iteration k ; σ^2 is the fitness variance of the swarms at iteration k; P_{max}, P_{min} is respectively, the maximum and minimum values of mutation probability, P_{min} is generally set to 0.

V. CAPACITY OPTIMIZATION OF STANDALONE HYBRID WIND/PV POWER SYSTEM

Independent process to configure the power supply system for hybrid wind / PV, wind turbines lowest electricity costs of PV cells and the battery power supply configuration can be completed in accordance with reliability action:

(1) The default parameters

The population of particles, each sample was tested up to sixty Run = 40 and C1 = C2 = 2.05 the accelerating factor mutation particle swarm limited in potential between 0 and 0.4.

(2) Particles with random position and initial velocity are set to start at 0.

(3) calculate the fitness of each agent and Xpbest and Xgbest;

(4) Exercise Reed (23) for admission;

(5) The possibility. Mutation (24) is calculated by using;

(6) To find a new point (21) is calculated using (20), mutations in which agents are required.

If you are unable to reach an advanced PSO algorithm to reproduce (7) and k = k +1, and (3) to set the stage.

(8) Output for the best solution.

VI. SIMULATION RESULTS

In this paper, the calculation was done based on a certain region selected as an example with geographic latitude of 36o48'. The wind speed data (8760 hours), solar radiation data (a typical 24- hour of the month of 1,4,7,10), the load data (8760 hours) as follows:

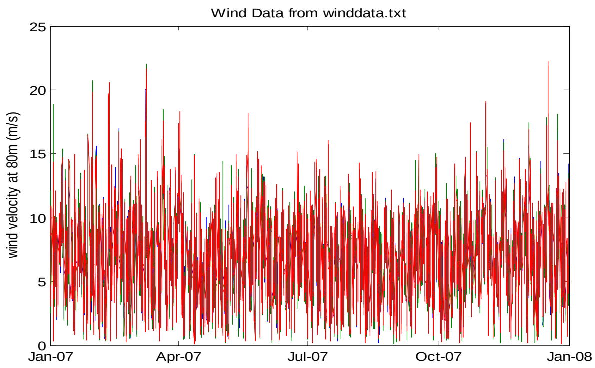

Fig.3 Wind speed

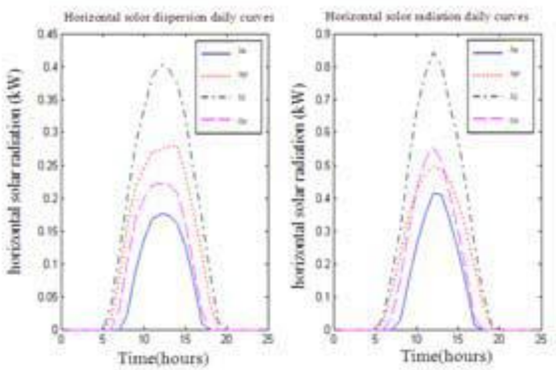

Fig.4 Solar irradiation

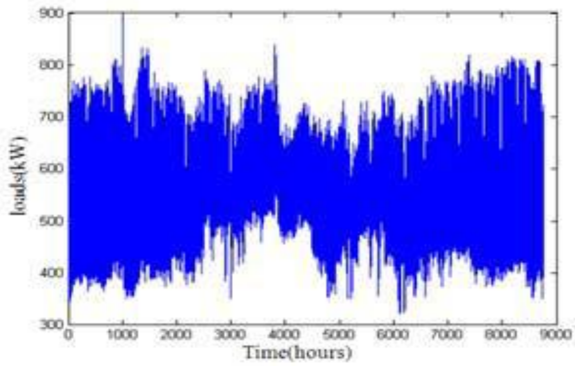

Fig.5 Load

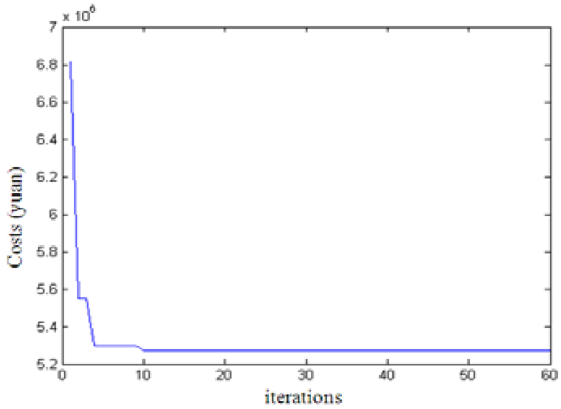

Fig.6 Process of evolution

The specific parameters used for computing are shown in table 1, where a mix of different types of turbines will not be taken into consideration, but only a single type of turbine as an example for demonstration.

Tab.1 System parameters

System parameters	Parameter values
Rated power of the wind turbine	600kW
Cut-in wind speed of the wind turbine	3m/s
Rated wind speed of the wind turbine	12m/s
Cut-off wind speed of the wind turbine	25m/s
Life expectancy of the wind turbine	20 years
Cost of the wind turbine	3,900,000 RMB
Cost of PV cells	4000 RMB
Open-circuit voltage of PV cells	29.2V
Short-circuit current of PV cells	8.09A
maximum power current of PV cells	7.42A
maximum power voltage of PV cells	23.6V
Life expectancy of PV cells	22 years
Rated power of the battery	12kW
Rated voltage of the battery	12V
Depth of discharge	50%
Life expectancy of the battery	10 years
Cost of the battery	7000 RMB
Discount rate	0.06

The final scheme of the capacity configuration obtained by using the improved PSO algorithm has been shown in table 2:

Tab.2 Optimal solution

Parameters	*Parameter values*
Best inclination of PV cells	$17^0 45'$
Number of the wind turbine	5
Number of PV cells	203×10
Number of the battery	65×20
Minimum cost	5.2705×10^6
LPSP	0.0287

It turns out that solar power in the summer than compensate for the lack of geographic latitude air assets installation location is smaller than can be seen from Table 2 turbines, PV cells and the battery will be paid accordingly. Table 2 and change the number of solar cells and solar cells will turn into the relationship between changes in total costs can be drawn.

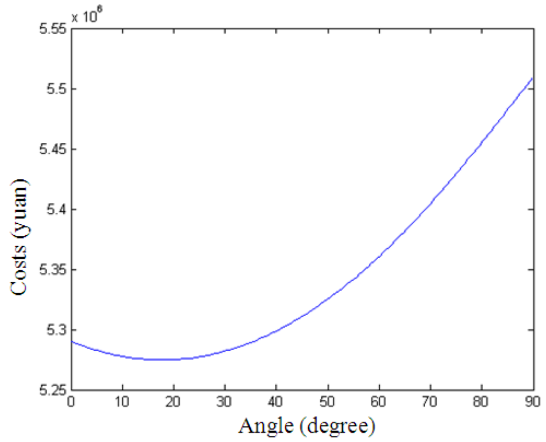

Fig.7 The relationship between Photovoltaic angle and total costs

From the figure it can be seen that the best inclination is 17^0 or so and the property of the best configuration provided by improved PSO algorithm has been verified. The power curves of turbines, PV cells, batteries and the load demand (from 3800 hours to 4000 hours in a whole year) are shown in Fig. 8:

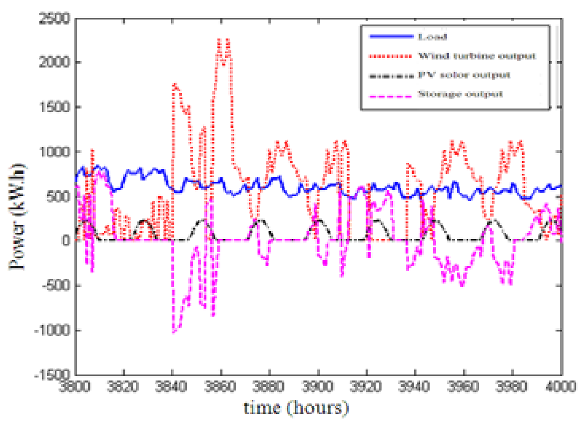

Fig.8 Change of storage capacity \Photovoltaic power \Wind power

From the Fig. 8 it can be seen that wind power is very unstable and varies considerably, however, PV cells and batteries can supply very good so that it guarantees reliable power supply for residents.

VII. CONCLUSIONS

Optimization of advanced algorithms based on PSO. Reliability electric hybrid wind / PV stand-alone project that will be added to the function of the target, which reduces the energy consumption of the system is fixed, and in this article is proposed to adjust. Compensation factor is reliable, easy management and control of the facilities to be provided by variable in determining the optimization algorithms traditional solar cells and batteries only, but kind and the number of turbines and solar panels for the project will change. More accurate results

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