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SOLUTION OF SOLAR ENERGY-BASED DIFFERENT LOAD DISPATCH PROBLEMS USING BSA-PSO HYBRID ALGORITHM

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Abstract: : One of the important research priorities for decades has been reliable and cheap energy supply. Different approaches have been developed for economic dispatch (ED) in order to resolve the continuous problem of sustainable energy production at optimized prices. Rapid fuel price increases, fossil fuel supply exhaustion, and environmental challenges have pushed people into the energy mix to integrate Renewable Energy (RE) tools. This paper proposed a method for solving these problems, i.e. traditional ED and RE based ED, with the hybrid backtracking search algorithm (BSA) and particle swarm optimization (PSO) algorithm. Thirteen photovoltaic (PV) plates with a solar power generation unit are considered here, with fifteen and forty test systems. Proposed solar powered test systems are used to assess optimum generation cost using the BSA-PSO hybrid algorithm, simple BSA and PSO. Proposed hybrid BSA and PSO algorithm is better than the standard BSA, PSO, sine cosine algorithm, whale algorithms and mine blast algorithm as compared to their simulation performance.

Keywords: Economic Load Dispatch, Particle Swarm Optimization, Combined Economic Emission Load Dispatch, Backtracking Search Algorithm.

1. INTRODUCTION

There has been extensive research worldwide into sustainable, renewable and effective energy production systems to satisfy increasing population requirements and to limit widespread fossil fuel use. The amount of renewable energy resources has dramatically increased with increasing energy costs, environmental issues and the gradual decline of the established fuel supplies.

The primary function of economic load dispatch (ELD) is to ensure that the electricity generation system is run most effectively. The ELD's primary aim is to reduce fuel costs. The lowest cost function through optimization techniques is a common area of study. A significant factor in the working of the energy system is RE based ELD and the optimum power generation.

The output energy of the unit or unit which is provided for the given load is referred to as the ELD to reduce the overall cost of fuel. To calculate the cost of generation, each generator uses special cost coefficients for each unit. The key goal of ELD is to split electricity between the generating units involved to satisfy market requirements and minimize the costs of production. The sum of the overall produced power is equal to the pre-compulsory power, if the transmission loss is neglected. This makes the solution process even simpler. If transmission losses are involved in the process, the ELD decision is challenging. Optimal value of the optimization problem would then be determined by a new technique.

A Literature survey reveals that issues with ELD have been addressed over the years, using multiple system forms. Here are a couple of techniques.

A paper discusses the implementation of the backtracking search algorithm (BSA) and particle swarm optimization (PSO) hybrid algorithm [1] to the combined economic emissions load dispatch (CEELD) problem. BSA-PSO, the new hybrid optimization, is a BSA and a PSO. A variety of soft computing techniques have recently been used to solve this issue. In order to address this issue, various types of price penalty factors were considered. Price cancellations include Min-Max, Max-Min, Max-Max and Min-Min prices. The CEELD penalty factor is the fuel cost-to-fuel ratio. In the case of the CEELD issue, the valve point effect was also applied. A comparison and analysis were carried out on the application of several price penalty factors to the CEELD conundrum. In view of the influence on the valve points and the different price penalty factors, the optimal fuel costs have been demonstrated using the hybrid BSA-PSO algorithm. The BSA and PSO approaches were compared with the optimal fuel prices arising from the relevant algorithm.

Another paper suggests the introduction of a complicated constrains-based ELD where BSA [2] was applied to reduce generation cost. ELD is a significant optimization problem. At present, issues with ELD have been addressed by different forms of information technology. Fifteen-unit test schemes were considered and resolved using the BSA methodology. The optimum fuel cost of the applied BSA technique has been comparable to the PSO, PSOCFA, PSOIWA and PSOCFIWA techniques.

Inter Symbol Interference (ISD) is the principal element of the Digital Communication System that affects data reliability. At the end of the communication system, a channel equalizer is used to mitigate this effect. It is an inverse probability model whose coefficients are adjusted by using a different optimizing algorithm. This PSO-ECF [3] algorithm is matched by an optimization algorithm for channel equalization based on PSO vector constriction factor (PSO-VCF) (LMS). They noted that the PSO-ECF algorithm of these authors had been superior to the other algorithms used in this study, both MSE and BER. It has also been critical to be efficient.

The public environment is getting more and more dynamic with the growth of the economy and increasing population mobility. An important aspect of an intelligent city is the control device. Goal tracking is a crucial aspect of the control system. Tracking is an optimisation process, but evolutionary algorithms can be used to overcome it. In the traceability problem, both PSO [4] and Quantum-behaved PSO (QPSO) have been used commonly as high precision evolutionary algorithms with rapid convergence, which have attracted increased interest. Many tests, however, indicate that PSO and QPSO both have underlying weaknesses. They are decreasing in the context of monitoring applications as they slip into the local peak and are more time-consuming. To achieve the goal, a novel method called random drift PSO (RDPSO) was used. RDPSO increases global integration and performance relative to PSO and QPSO. A sequential RDPSO tracking algorithm based on the conventional PSO-based tracking system is proposed. Particle initialization is adjusted, merged resampling steps in the particle filter (PF) to further boost the efficiency of the proposed monitoring algorithm, and used the Gaussian model for fitness evaluations. Many test results demonstrate the efficiency of this algorithm of the authors, in particular when the context changes considerably, when the target is deformed or when the camera shakes rapidly.

The architecture and operation of the electricity grid, which is dynamic, nonlinear, and non-stationary, is a mystery. There are several uncertainties. The aim is to act as an intelligent smart electricity grid and keep it running in stable conditions, with minimal variance, advanced analytical methods for planning and optimization, quick control, field data processing and teamwork throughout the power system. A detailed and accurate short-term load forecasting (STLF) [5] is one of the key aspects of such a system. This article presents an STLF paradigm using a common day definition paired with an emerging logic approach and an evolutionary PSO (EPSO) strategy. A Euclidean distance range with weight factors based on temperature and day form is used to identify related days. The fuzzy logic is used to generate the corrector for the selected load curves on the forecast days. The input parameters for the flowing method include the average load, temperature average and moisture variations of the previous day's forecast and related days. Related days of estimation are implemented for these mitigating variables. Fuzzy input parameters are tuned using the EPSO technique for the training and testing of the results. The results of the load prediction indicate the best performance of the EPSO fluid tuning system (without EPSO).

In this paper, the algorithm updated to overcome the CEELD problem of the power system is proposed for modified biogeography-based optimization (MBBOs) [6]. Few non-linearities are considered, such as the lack of transmission and valve loading points. The primary goal of CEELD is to distribute energy supply to meet demands for loads within their limits, where costs and pollution are also minimized. The ecological distribution of the ecosystem deals with biogeography. Three separate evaluation structures with fair justice and discrimination requirements have been developed to validate the proposed MBBO algorithm. The results are checked with other techniques that are beneficial to the proposed MBBO algorithms. The results are evaluated.

This paper introduces a solution to the problem of dynamic economic distribution (DED) through the integration of bacterial foraging optimization (BFO) [7], PSO and differential evolution (DE) and of a hybrid optimization methodology for bacterial forage and PSO-DE (BPSO-DE). BFO performs local searching and global searching for whole search spaces by the PSO-DE operator, so that global optimization can be achieved. The BFO also takes care of restrictions like ramp-rate limitations, valve loading effects, demand for system loadings, and banned areas of operation, power losses and the capability of a spinning reserve. The effectiveness of the proposed method compared to other existing methods is considered in a ten-unit test system.

In view of the ever-moving movement of a car in an uncertain environment, this paper presents an H-inf static feedback control strategy based on an active suspension hybrid PSO-DE/ LMI algorithm [8]. A new hybrid algorithm is proposed to solve an optimization problem with bilinear uniform matrix (BMI) constraints on the base of a lines uniform matrix (LMI) method and two types of population based evolutionary algorithms: a PSO algorithm and a DE algorithm. The proposed hybrid algorithm improves the convergence rate and accuracy of the DE-LMI algorithm and is used to design the active suspension H-inf static output controls. The simulation results show that the designed controller effectively reduces the vehicle body's vertical and pitch acceleration and therefore the proposed approach can improve vehicle riding comfort.

The lack of energy supplies, the rise in the cost of producing electricity and the ever-increasing demand for electricity need maximum economic stability in today's power systems. The key goal of economic dispatch is to reduce the marginal cost of producing electricity while at the same time meeting the various restrictions of equity and inequalities. Traditionally, in the event of economic dispatch problems, the cost function of generating units has been approximated as a quadratic function that does not yield reliable The lack of energy supplies, the rise in the cost of producing electricity and the ever-increasing demand for electricity need maximum economic stability in today's power systems. The key goal of economic dispatch is to reduce the marginal cost of producing electricity while at the same time meeting the various restrictions of equity and inequalities. Traditionally, in the event of economic dispatch problems, the cost function of generating units has been approximated as a quadratic function that does not yield reliable results. In addition, the influence of the valve point in the thermal power plant must be considered in order to achieve correct fuel costs. The added valve point impact makes it more realistic to simulate the fuel price functions of generating units. In this work, a novel evolutionary hybrid algorithm i.e. hybrid PSO-DE was used to tackle the valve-point-effect problem of economic transportation. The hybrid PSO algorithm combines evolutionary operators in the normal PSO algorithm, such as selection and mutation. The method synergistically merges PSO with one big member of the DE family [9]. The non-linear cost function for 3-unit systems is solved using hybrid PSO technologies and results are contrasted with the conventional PSO, DE, and GM approaches. These results show that the Hybrid PSO approach is able to provide better quality solutions, including easy mathematics and fast convergence. Coach The efficient and robust solution is heuristic optimization. The paper proposes a novel hybrid algorithm, DE-PSO, which integrates DE with the PSO [10]. F and CR are analogous to two self-adjusted nonlinear functionalities to align human discovery and extraction capacities in various emerging periods. Taking into consideration the diverse population distribution, DE changes the mutation rate F, and the crossover rate CR accordingly. Particle upgrades are done by PSO systems and not just by the DE operator. DE-PSO preserves demographic stability and strengthens the potential for global integration. It also increases efficacy and success and prevents premature convergence. Simulating and comparing the effectiveness, consistency and robustness of the proposed algorithm based on test sets of CSPs.

In today's power system operation and control, the reactive power distribution aspect has been given considerable attention. The monitored reagent sources, distributed across the transmission network, manage the voltage regulation at heavy/light load times. As a nonlinear restricted optimization problem, a reactive power dispatch problem may be formulated. This article presents a particle swarm with differentially perturbed velocity (DV) (hybrid PSO-DV) [11] for optimal reactive power dispatch and voltage control of power systems. This article presents a Particle Swarm of differentially disrupted speed. PSO-DV is used on an IEEE 30-bus system to optimize reactive power delivery in order to minimize the transmission loss of power from the system by using bus voltage control, the tap-position of transformers and reactive power sources. The results of the simulation illustrate the reliability and solidity of the solution suggested.

Traditionally, heuristic methods are used to identify the scale and location of compact FACTS instruments in small power systems. However, more specialized methods are needed to place them on a large power network. The PSO methodology was recently used to solve problems of maximizing energy engineering and has yielded better results than classical approaches. This document illustrates the implementation of PSO [12] in the power system to maximize the scale and assignment of a STATCOM static compensator. A 45-bus grid (part of the Brazilian power network) is used to demonstrate the technique. The findings show that the PSO will find the best statistically valid and strongly convergent solution. There is also a comprehensive overview of the process, effects and observations.

The design of the particle swarm [13] is used for the development of a complex programming adaptive programming network and an essential network. The typical designs for adaptive dynamic programming and PSO are described as compared to other learning methods such as gradient descent approaches. In addition to a simulation of the balance of a cart pole farm, a more advanced plant pendulum robot (pendulum) was examined. In comparison with classic adaptive dynamic programming methodologies, the suggested evolutionary learning technique shows greater convergence and efficiency. The scheme is generally evident since the plant model needs no previous recognition.

The typical travel salesman problem (TSP) [14] consists of evaluating a tour in a weighted diagram (i.e., a loop which takes each vertex exactly once) in order to minimize the weight of the edges on this tour. Centred on natural heuristics, hybrid approaches have shown that they are capable of providing high-quality TSP solutions. A hybrid algorithm has been popular because there is a balance between the ability to manipulate and manipulate in the quest field. This article introduces a new hybrid model of the blind TSP based on particle swarm optimization and fast local search. The model is presented in detail and its hybrid characteristics are highlighted. The control parameters have been carefully modified and instances in 76 to 2103 cities have been checked for the device. The best results were less than 1% over the established optima in 439 towns, for example. The figures are, on average, 2.538 percent in both cases. The findings of the simulation suggest the robust efficiency of the proposed hybrid model. The SES findings promote further study and development of the hybrid model to resolve serious mixing issues.

For decades, the dispatch of electricity at minimal thermal energy source running costs has been a big part of science. With increased interest in green energy resources, optimum economic dispatch has recently become a challenge. It presents a hybrid emission-efficient distribution model [15] for an integrated solar photovoltaic energy grid with many solar and thermal plants. Different conditions of practice are constructed for binary mixed integer programming. The original problem is separated into 2 subproblems by a decomposition framework.

A power network can be made up of electricity due to the rapid growth of renewable energy technology and various green energy options. Power supplies have a wide range of operating costs and efficiency levels. The issue in this analysis is the Environmental Economic Dispatch (EED) [16] of hybrid electricity, including wind and solar thermal energy. Solar energy is introduced in this work with fifteen units and forty units of thermal ELD problems to meet the demand for power of the proposed model, i.e. solar energy [17] based ELD, is presented by obtaining optimal fuel cost using a hybrid BSA-PSO, BSA, PSO, sine cosine algorithm (SCA), whale algorithms (WA) and mine blast algorithm (MBA).

2. PROBLEM FORMULATION

The ELD problem was required to minimize all fuel costs in accordance with the limits.

A. Objective function

The power generated by a solar plant [17] can be represented as

$$P_{gs} = P_{rated}\left\{1+(T_{ref} - T_{amb}) \times \propto\right\} \times \frac{S_i}{1000} \qquad (1)$$

where P_{rated} is rated power, T_{ref} is the reference temperature, T_{amb} is the ambient temperature, $\propto$ is the ambient temperature, is temperature coefficient and S_i is the incident solar radiation.

With the inclusion of m solar plants in the dispatch, the solar share (the scheduled solar power) is provided as:

$$Solar\ Share = \sum_{j=1}^{m} Pgs_j \times Us_j \qquad (2)$$

where Pgs_j is power available from jth solar plant and Us_j denotes status of solar j^{th} plant which is either 1 (ON) or 0 (OFF).

The cost of solar power is represented as follows.

$$Solar\ cost = \sum_{j=1}^{m} PUCost_j \times Pgs_j \times Us_j \quad (3)$$

where $PUCost_j$ is per unit cost of j^{th} solar plant. Remaining power is generated by thermal.

The four-point function is used to measure each thermal power unit's fuel energy. Full costs may also be conveyed with respect to actual power generation.

$$\min f = \sum_{i=1}^{n} a_i P_i^2 + b_i P_i + c_i \quad i = 1,2,3......, n \quad (4)$$

where the number of units produced is n.

B. Constraints

(i) Power balance constraints

The generated power should be the same as the total power PD demand (in MW). There is an equalization of active power. Ps is the solar power.

$$P_D = \sum_{i=1}^{n} P_i + Ps \quad (5)$$

Losses in the generator and transition are ignored

(ii) Generation limits

These limits are connected to the output power of each generator at the top and bottom.

$$P_i^{min} \leq P_i \leq P_i^{max} \quad (6)$$

(iii) Ramp-rate limit constraints

$$\max\left(P_i^{min}, P_i^0 - DR_i\right) \leq P_i \leq \min\left(P_i^{max}, P_i^0 + UR_i\right) \quad (7)$$

3. BSA-PSO HYBRID OPTIMIZATION

BSA is the search algorithm for backtracking and an algorithm focused on the population. This algorithm for BSA [18] was recommended in 2013 by Pinar Civicioglu. Eberhart and Kennedy proposed PSO [19] in 1995. PSO is also an algorithm based on the population. The standard approach to optimization is BSA-PSO. The collection has its own set of criteria and produces good results. The converging character of both BSA and PSO is nice. BSA-PSO hybrid optimization is a technique of considerable significance, stable, transparent and efficient. The five measures include Crossover, Mutation, Initialization, Selection-I and Selection-II. PSO is the beginning. This describes and recombines the positions and speeds of gbest&pbest particles.

The hybrid BSA-PSO approach [11] integrates, produces convergence and optimal results, the best of the BSA and PSO parameters. The initialization actions of BSA and PSO [20] are normal. Components are generated spontaneously under their generation limits with the formula.

$$P_{i,j} \sim U\left(low_j, up_j\right) \quad (8)$$

where $i = 1,2,3......, N$ and $j = 1,2,3,......, D$

The fitness expense of particles is determined by objective function and the particle volume (variables) (s) as pbest. For selection-I, particles in their so-called old population are spontaneously regenerated with equation (9).

$$oldP_{i,j} \sim U\left(low_j, up_j\right) \quad (9)$$

Real number equivalents 0 and 1 are used by the formula (10), g and h. Since the old population was created, suggested by the old P.

$$\text{if } g < h \text{ then } oldP := P \mid g,h \sim U(0,1) \quad (10)$$

Reformed oldP is allowed with below equation.

$$oldP := permuting\ (oldP) \quad (11)$$

In this way, selection-I is made. The mutation process starts at the end of selection I. A formulation mutation is used at this stage (12). For the development of mutation members, Formula (9) is used.

$$mutant = P + F \times (oldP - P) \quad (12)$$

Here F is seen as a random value producing 0 and 1, respectively.

The convergence process starts after the fusion point. The mutant standard of the trail population (T) is first considered during this process. The final form of the sample population is named for the crossover section. Originally, Crossover consists of two stages. The first step is to change the value of T using the binary-integer matrix array using P values.

If $map_{n,m} = 1$

Whrer $n \in \{1,2,3,........,N\}$ and $m \in \{1,2,3,........,D\}$

T is updated with $T_{n,m} := P_{n,m}$.

The last step of the crossover is stage two. The final trail particles have the fitness values calculated at this stage using the analytical form.
The velocity and location of the particles formed at the initial stage are changed with the formula (13) and (14).

$$v_{id}^{(k+1)} = w \times v_{id}^{(k)} + C_1 \times rand \times \left(pbest_{id} - x_{id}^{k}\right) + C_2 \times rand \times \left(gbest_{id} - x_{id}^{k}\right) \quad (13)$$

$$x_{id}^{(k+1)} = x_{id}^{k} + v_{id}^{(k+1)} \quad (14)$$

The new fitness values of the changed particle position are calculated using formula (4). These current fitness values for changed particle positions are compared with the last particle fitness values according to the overall particle health ranking.

The last stage of selection is the BSA-PSO Hybrid Algorithm-II. pbest or initialised particles are evaluated in accordance with their best fitness values at this step and are replaced with current particles. The best quality is considered pbest. The best patch in the world. Optimum effects would otherwise occur in the first instance where the parameters have been halted.

4. RESULTS AND DISCUSSION

Solar and thermal power plants are involved in meeting the ELD [21] problem's power demand. Different test cases of proposed solar based ELD problem are considered to show the effectiveness solar energy in ELD problem. In this study, thirteen photovoltaic (PV) plate-based solar power generating units with ten, fifteen and forty-unit test systems were considered. The BSA-PSO hybrid algorithm, basic BSA, PSO, SCA [22], WA [23] and MBA [24] are used to determine optimal generation costs in proposed solar-based test systems of the hybrid BSA-PSO is shown by determining the optimal generation cost of the considered test systems.

powered ELD to the traditional ELD. The convergence behaviour of the hybrid BSA-PSO, BSA and PSO is shown in Fig.3. The solar unit generates 11% of total power, while the thermal unit generates the remaining 89% of total demand power. A graphical expression of the generated power of solar and thermal units is expressed in Fig.4.

Table 3: Optimal power generation of solar based ELD problem using hybrid BSA-PSO (fifteen thermal units and one solar unit).

Unit of power output (MW)	BSA-PSO(Proposed)	BSA (Studied)	PSO (Studied)	SCA (Studied)	WA (Studied)	MBA (Studied)
TU1	420.4098	255.8622	298.9715	563.8645	423.1537	357.7970
TU2	323.9825	329.8905	373.5405	221.9663	150.0000	411.3698
TU3	140.0499	153.8811	131.3998	165.0280	182.0163	100.0334
TU4	168.0921	144.0250	63.9349	125.8705	328.6903	174.3110
TU5	150.7357	164.4934	164.6759	165.2811	158.2361	192.3083
TU6	341.4811	276.3698	449.7631	464.9975	539.3705	395.0224
TU7	299.3873	485.4472	430.8476	438.9900	135.0000	315.2871
TU8	121.0457	203.9470	138.9956	60.0000	153.5585	60.0000
TU9	128.2859	25.0000	87.0622	25.0000	44.1009	110.8970
TU10	91.8539	211.6901	89.4863	25.0000	42.6973	171.1075
TU11	24.5571	24.4245	30.2291	64.6668	80.5470	76.5534
TU12	30.5053	76.5610	83.1595	20.0000	97.5787	85.8184
TU13	47.5852	25.0000	29.1914	25.0000	83.1403	30.6292
TU14	39.7678	15.0000	57.1273	83.4672	15.0000	37.6240
TU15	15.0639	15.0329	15.4692	15.9959	47.9935	15.5091
SU1	287.1968	223.3753	186.1461	164.8723	148.9169	95.7323
Total cost($/hr)	29626	30209	30674	30699	30974	31548

Table 4: Comparison of generation cost of solar based ELD with traditional ELD

Method	Optimal fuel cost (solar based ELD)($)	Optimal fuel cost (traditional ELD) ($)
BSA-PSO(Proposed)	29626	31550
BSA(Studied)	30209	31700
PSO(Studied)	30674	32050
SCA(Studied)	30699	32180
WA(Studied)	30974	32400
MBA(Studied)	31548	32660

Table 2: Comparison of generation cost of solar based ELD with traditional ELD

Method	Optimal fuel cost (solar based ELD)($)	Optimal fuel cost (traditional ELD) ($)
BSA-PSO (Proposed)	90734	100010
BSA(Studied)	96606	103538
PSO(Studied)	100490	109913
SCA(Studied)	105110	115046
WA(Studied)	105530	115889
MBA(Studied)	107710	119207

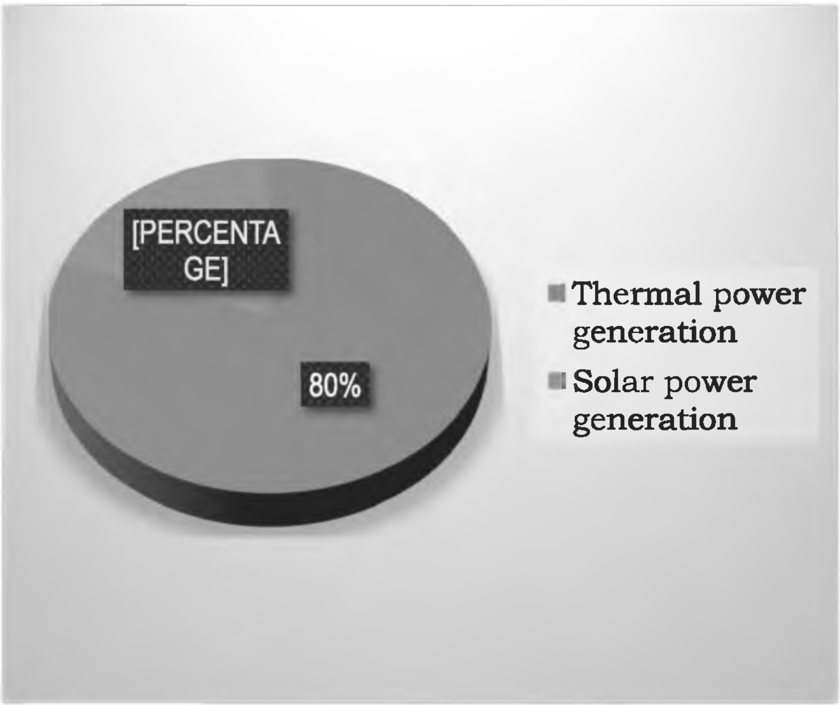

Fig. 2: Graphical expression of solar and thermal power generation.

4.2. Case study II

In this case study, fifteen thermal units and one solar unit are considered to fulfil the demand power, i.e. 2630 MW. The proposed test case is used to calculate the cost of generation using a hybrid BSA-PSO. Different constraints for the considered test case are taken from [17] and [21]. Optimal power generation, as obtained using hybrid BSA-PSO, is tabulated in Table 3. Optimal generation cost obtained by hybrid BSA-PSO is 29626$ (see Table 3). Comparison of the results of the hybrid BSA-PSO with BSA and PSO are shown in Table 4. The effectiveness of solar in ELD is demonstrated by lowering generation costs associated with traditional ELD issues. Table 4 compares the solar-powered ELD to the traditional ELD. The convergence behaviour of the hybrid BSA-PSO, BSA and PSO is shown in Fig.3. The solar unit generates 11% of total power, while the thermal unit generates the remaining 89% of total demand power. A graphical expression of the generated power of solar and thermal units is expressed in Fig.4.

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TU2	323.9825	329.8905	373.5405	221.9663	150.0000	411.3698
TU3	140.0499	153.8811	131.3998	165.0280	182.0163	100.0334
TU4	168.0921	144.0250	63.9349	125.8705	328.6903	174.3110
TU5	150.7357	164.4934	164.6759	165.2811	158.2361	192.3083
TU6	341.4811	276.3698	449.7631	464.9975	539.3705	395.0224
TU7	299.3873	485.4472	430.8476	438.9900	135.0000	315.2871
TU8	121.0457	203.9470	138.9956	60.0000	153.5585	60.0000
TU9	128.2859	25.0000	87.0622	25.0000	44.1009	110.8970
TU10	91.8539	211.6901	89.4863	25.0000	42.6973	171.1075
TU11	24.5571	24.4245	30.2291	64.6668	80.5470	76.5534
TU12	30.5053	76.5610	83.1595	20.0000	97.5787	85.8184
TU13	47.5852	25.0000	29.1914	25.0000	83.1403	30.6292
TU14	39.7678	15.0000	57.1273	83.4672	15.0000	37.6240
TU15	15.0639	15.0329	15.4692	15.9959	47.9935	15.5091
SU1	287.1968	223.3753	186.1461	164.8723	148.9169	95.7323
Total cost($/hr)	29626	30209	30674	30699	30974	31548

Table 4: Comparison of generation cost of solar based ELD with traditional ELD

Method	Optimal fuel cost (solar based ELD)($)	Optimal fuel cost (traditional ELD) ($)
BSA-PSO(Proposed)	29626	31550
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PSO(Studied)	30674	32050
SCA(Studied)	30699	32180
WA(Studied)	30974	32400
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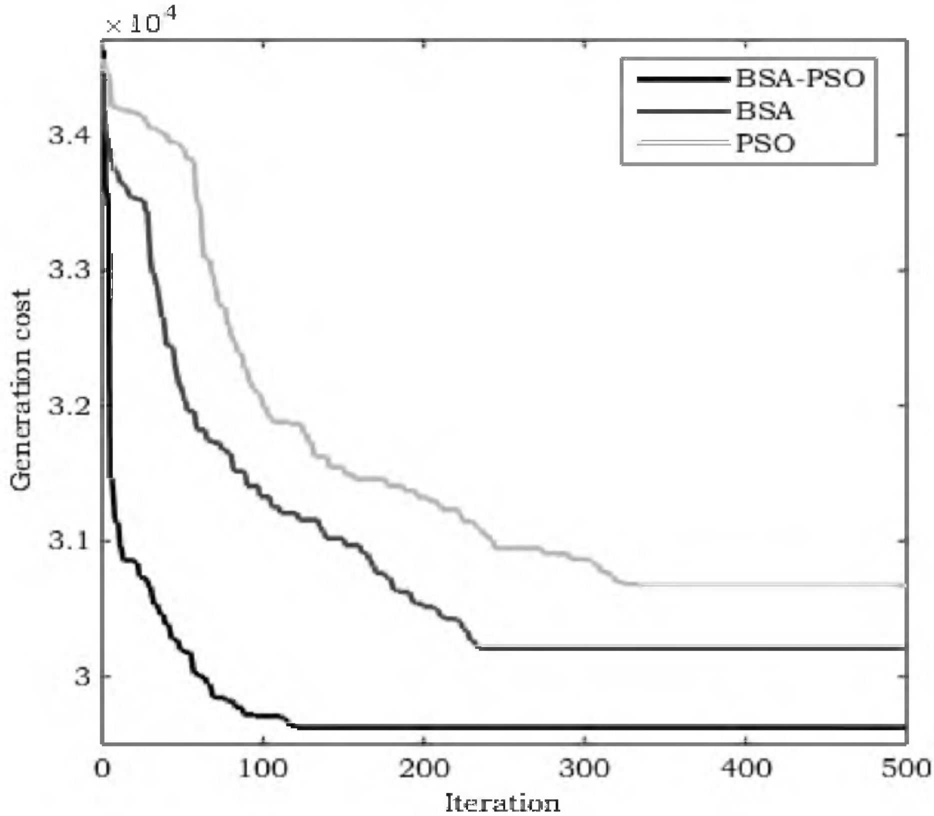

Fig.3: Convergence behaviour of the BSA-PSO, BSA and PSO method for 15-unit System (PD = 2630MW)

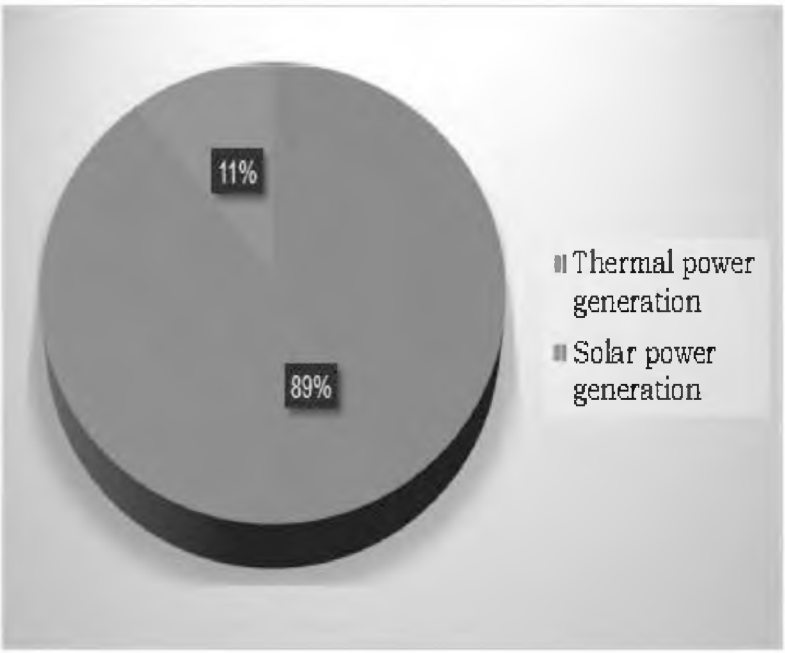

Fig.4: Graphical expression of solar and thermal power generation.

4.3. Case study III

The efficiency of the proposed ELD model, i.e. solar-based ELD, is demonstrated by calculating the generation costs of forty thermal and one solar unit-based systems. Here, the hybrid BSA-PSO is used to determine the optimal generation cost of a considered test case of a solar-based ELD. System constraints of solar-based ELD are taken from [17] and [21]. The optimal generation of the considered test system is presented in Table 5. The optimal generation cost of the test system is presented in Table 5. The effectiveness of BSA-PSO is demonstrated by comparing its results to those of BSA, PSO, and other algorithms (see Table 6). Proper application of solar energy to the ELD problem is shown by reducing the generation cost of the traditional ELD problem. The convergence behaviour of the BSA-PSO is shown in Fig.5. Fig.6 depicts the contribution of solar and thermal to the demand for power fulfillment.14% and 86% percent of demand power are generated solar and thermal units respectively.

Table 5 : Optimal power generation of solar based ELD problem using hybrid BSA-PSO (fifteen thermal units and one solar unit).

Unit of power output (MW)	BSA-PSO(Proposed)	BSA (Studied)	PSO (Studied)	SCA (Studied)	WA (Studied)	MBA (Studied)
TU1	65.2225	43.5757	76.1254	56.3907	58.0330	74.8263
TU2	60.0001	68.6878	82.4678	72.1859	78.4521	80.7696
TU3	131.6577	87.3578	83.1812	101.5973	131.2551	119.2470
TU4	35.6733	24.0000	24.0726	42.1372	35.2881	42.6565
TU5	30.6659	29.1910	31.3310	36.0864	33.9025	33.1262
TU6	91.2683	90.0345	68.0000	79.6406	89.5982	93.1716
TU7	154.7524	110.0000	111.1818	130.9864	123.6954	118.4618
TU8	182.5148	185.5924	200.3318	227.8766	188.7191	151.5727
TU9	145.2945	197.6473	225.1676	200.7752	197.2768	208.7440
TU10	146.6148	130.0000	135.2739	145.7440	163.9816	134.0154
TU11	293.4843	272.5655	276.0881	304.8595	272.9776	299.0688
TU12	253.6204	205.0000	371.4333	249.6184	255.8874	347.8697
TU13	178.1628	125.0000	156.1590	147.9606	165.8942	173.4314
TU14	125.0000	192.3633	201.6711	145.0999	177.9504	205.1160
TU15	148.9916	185.3422	177.2792	141.6023	178.3928	167.5559
TU16	245.7629	162.6339	125.0000	182.9185	136.5566	142.3884
TU17	225.3539	161.6446	259.5640	226.8224	159.8290	269.2769
TU18	414.8570	377.3643	399.3359	311.5767	372.8267	299.5756
TU19	398.9801	471.7370	432.0535	387.2328	406.5927	329.7104
TU20	381.0588	485.8099	373.8098	401.5367	375.3601	293.1847
TU21	415.4724	421.3861	368.7622	336.2035	415.4985	375.3968
TU22	328.0512	538.2650	296.5487	435.1232	333.1161	432.0743
TU23	316.1851	394.6775	457.0526	389.2250	333.8995	422.9253

Unit of power output (MW)	BSA-PSO (Proposed)	BSA (Studied)	PSO (Studied)	SCA (Studied)	WA (Studied)	MBA (Studied)
TU24	368.3787	384.3708	317.8631	342.6237	410.0930	332.5111
TU25	456.7250	280.0000	406.3074	353.7354	329.9154	315.2019
TU26	318.6913	280.0000	297.8375	397.4836	411.6473	348.8423
TU27	329.1783	315.8350	310.6233	396.4907	363.5794	455.1575
TU28	35.3665	10.0000	10.0000	29.7763	15.9059	10.0000
TU29	23.5582	39.4003	30.9064	24.6115	40.2917	10.0000
TU30	15.4356	10.0000	23.1372	24.2161	31.8386	16.0269
TU31	31.7240	43.2645	38.2765	45.8878	34.0158	20.0000
TU32	30.0621	23.9892	67.4053	21.8636	56.1195	63.6449
TU33	41.9994	53.9848	20.0000	22.3038	60.6584	39.8578
TU34	40.3835	65.8482	43.5467	34.7551	38.4692	22.0172
TU35	22.1052	21.2685	24.5478	28.3920	31.0304	30.5565
TU36	26.4141	18.0000	26.0645	65.0020	25.6303	51.9431
TU37	31.9147	31.8279	20.0000	36.5696	39.6286	39.1018
TU38	25.3362	26.0379	31.5920	33.9795	37.2630	32.2311
TU39	31.2511	40.0541	39.9340	55.6379	28.8580	43.2113
TU40	25.2210	29.2693	25.0049	25.0008	25.0090	41.7422
SU1	377.6107	366.9737	335.0630	308.4707	335.0630	313.7891
Total cost($/hr)	101650	102180	103710	103860	104050	104610

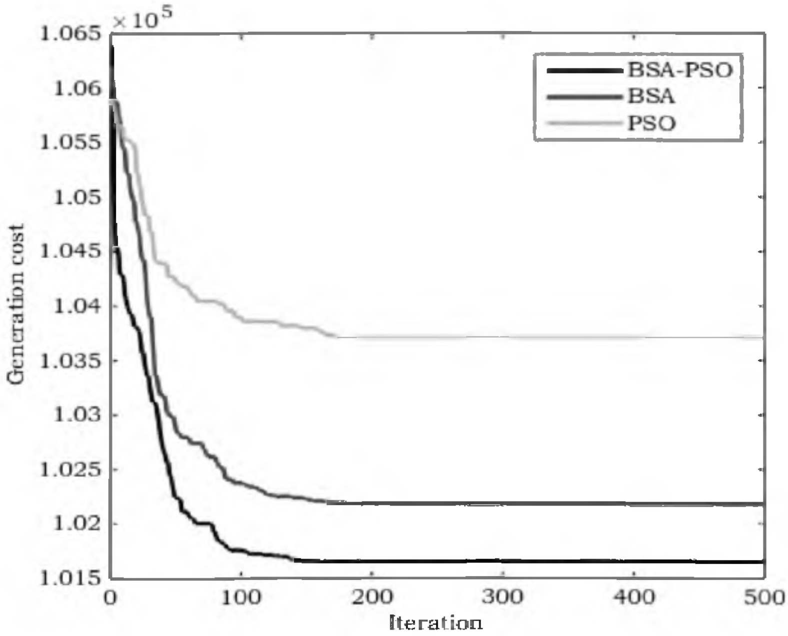

Fig.5 : Convergence behaviour of the BSA-PSO, BSA and PSO method for 40-unit System (PD=7000MW)

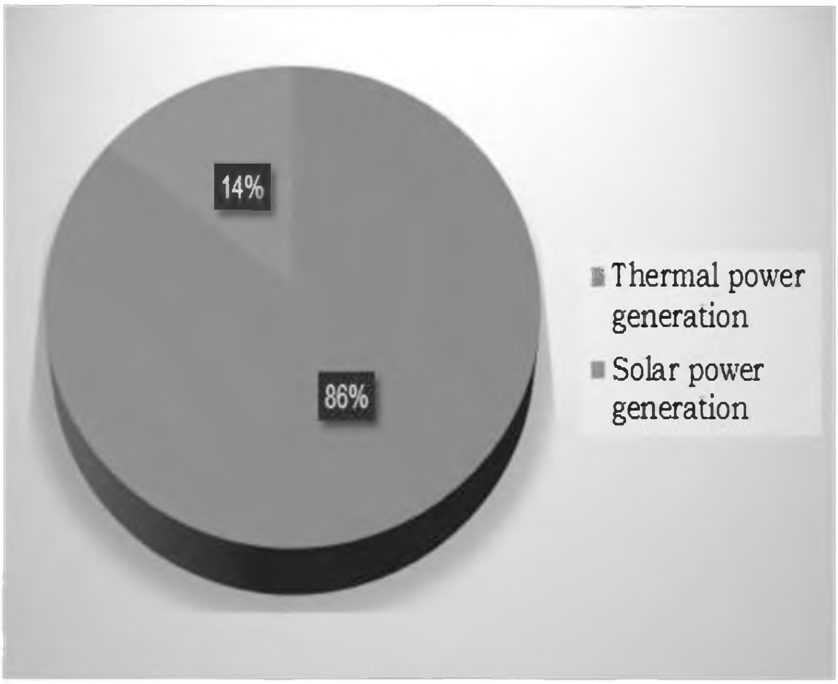

Fig.6 : Graphical expression of solar and thermal power generation.

Table 6 : Comparison of generation cost of solar based ELD with traditional ELD.

Method	Optimal fuel cost (solar based ELD)	Optimal fuel cost (traditional ELD)
BSA-PSO(Proposed)	101650	105770
BSA(Studied)	102180	106418
PSO(Studied)	103710	107301
SCA (Studied)	103860	107760
WA (Studied)	104050	108111
MBA (Studied)	104610	108516

5. Conclusion

BSA-PSO based hybrid algorithm is introduced to handle different cases i.e. generation cost and emission of thermal-solar based generation model. Solar and thermal plants meet the requirement for power for the ELD issue. Different test scenarios are studied to illustrate the effectiveness of solar energy in the ELD problem using the suggested solar-based ELD problem. The BSA-PSO optimization method was used in two case studies with fifteen thermal units and one solar system and forty thermal units and one solar system, respectively. Effectiveness of the proposed solar integrated ELD model has been identified by reducing generation cost of demand power from the generation cost of same demand power of traditional ELD problem. The results of the simulation show that the proposed model works successfully.

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