International Journal of Electronics and Microcircuits

E-ISSN: 2708-4507
P-ISSN: 2708-4493
IJEM 2022; 2(2): 24-32

www.microcircuitsjournal.com
Received: 12-05-2022
Accepted: 17-06-2022

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Development of solar thermal power generation using particle swarm optimization

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Abstract
This study analysed the thermal loss law of the recycled working material of the conventional thermal power generating unit and detailed the Solar Thermal Power System's primary construction and performance characteristics (STPS). In terms of technical viability and cost-effectiveness, the main technological constraints of the high-temperature solar thermal power system are outlined. Then, the unified operating system for conventional and solar thermal energy was introduced. This hybrid system may be driven by solar energy to create normal and low-temperature water vapour in order to efficiently utilise these technical shock points that arise at high-temperature solar thermal power. The combined operation of solar thermal energy and conventional heat power may be the most significant alternative to the reform of the energy conservation and environmental protection of conventional thermal power stations, as well as the most significant method of utilising solar energy efficiency on account of its higher overall efficiency and evident technical and economic performance.

Keywords: Solar power plants, conventional thermal power plants, solar towers, combined operation, and thermal energy generating systems

1. Introduction

The STPS is a solar thermal energy conversion system that combines concentrated solar radiation and a receiver to power a steam turbine, producing electricity via a thermal circuit. It is one of the primary ways solar energy will be used extensively in the future (Hossain, 2020) [1]. The Solar Thermal Power System (STPS) continues to have limitations that considerably limit its commercial use, such as expensive investment and cost per unit capacity as well as poor integrated system efficiency (Ibrahim, 2019) [2]. According to research, the STPS system has few technical issues, minimum building costs, and a high photo-thermal transformation efficiency when the operating temperature is below 360 degrees Celsius.

However, it has a poor generating system efficiency, resulting in high energy production costs. The operating temperature of the system should be increased to guarantee high efficiency in photo-thermal transformation and thermal circulation, which will increase the production system's and the system's overall efficiency. Implementation entails considerable technical obstacles and costs, as noted by Jlassi (2018) [3]. In conventional thermal power plant high or super high-temperature systems, design and construction techniques, equipment manufacturing, and maintenance skills are reasonably well-established. Overall, the system's efficiency is rather good. Nonetheless, the combustion of many fossil fuels concurrently would result in enormous pollution. According to an analysis of the overall fuel energy conversion process by the conventional thermal power plant's heater, more than 70 percent of the total heat absorbed by the thermal circulation is absorbed by the cycle-working fluid heating from the condensed water to the 360 ° C super-heated steam.

Therefore, the strategy for creating an integrated operating system was provided in this research based on the features above of STPS and conventional thermal generating power plants.

This designed system has high overall efficiency as a traditional thermal power production unit and successfully uses solar electricity to produce low- or middle-temperature steam. Additionally, it is possible to bypass the technological bottlenecks in high-temperature STPS. As a result, one of the most significant ways to use solar energy in the future may be through the joint operation of solar and conventional thermal power. Carbon fires, natural gases, or fossil fuels are used to power generators through mechanical connections to produce energy from the generator. This process produces greenhouse gases and is only moderately effective. Even though photovoltaic or solar cells need little maintenance, have a long lifespan, and have a high level of dependability, they are not frequently employed to provide alternative energy sources (Shaaban *et al*., 2021) [4].

Relying on seasonal factors, such as wind power, is relatively rare. It is also referred to as a static power source due to its semi-conductor nature and is simple to place as a solar farm on top of a structure, a curtain, or a piece of land. The electricity produced is connected to the grid, and a recent study has shown that grid-connected solar power is a promising field. A battery, a water storage tank, a superconductor, or a super-capacitor are energy storage systems that may store power for later use (Shahadat *et al*., 2013) [5]. It can also be used to connect to the grid, reducing the need for expensive energy storage. Solar cell connections in series and parallel are used to generate electricity from solar cells. The DC-AC inverter can be driven by the full connection increasing to a suitable voltage thanks to the series connection. Before the solar panel is linked to the inverter, the voltage is controlled by a DC-DC power converter. Another DC-DC converter offers MPPT (Maximum Power Point Tracking), which regulates the input voltage of the DC-DC converter to give the maximum power at varied sunlight intensity. The project and efficiency development in marine settings have received very little attention from researchers up to this point. Because it is simpler to maintain the environmental conditions of fresh water, the freshwater report is more prevalent (Singh, 2016) [7]. There is less corrosion, and wave or tidal movement is not considered. A floating unit is utilised in the maritime environment to fix the solar panel above the ocean level. This is crucial because prolonged seawater exposure can reduce the solar panel's lifespan and the electrical connections. The flat floating object is resting on ocean water. A certain tilt angle concerning the horizon must be built into the solar panel's design. The solar power and wind speed must be considered while choosing this tile angle.

1.1 Problem Statement

Varying sunlight receiving principles result in different technical and financial performances between solar power and solar power towers. Solar power plants often use the line focus form. Therefore, the structure's tracking and controlling subsystem's design and production are straightforward and relatively inexpensive. However, its line-focus shape causes the drawbacks of a low concentration, lengthy heat transfer loops, and substantial heat losses. The heat transfer fluid should operate at less than 400 ° C. The receivers' emissivity increases by 104 times at higher working temperatures, which lowers their photo-thermal conversion efficiency. As a result, solar power plants may use it for functioning at temperatures below 400 ° C. In addition, a huge mid-temperature thermal power plant may be constructed with multiple concentrations and receivers organised through series-parallel links, depending on its structural properties.

1.2 Justification

In order to collect solar radiation, solar power tower plants use a focusing form. Advantages over a trough include high concentration, high operating temperature, short heat transfer loops, reduced heat losses, etc. Thus, it is suitable for commercial applications needing high capacities (between 30 and 400 MW), such as Tiller (2017) [8]. When the solar power tower operates at medium temperature (approximately 400 ° C), the heat transfer fluid and the heat storage medium can be selected easily, thereby avoiding a number of unanticipated technical issues associated with the transfer and storage of high-temperature and high-pressure fluid. Low heat emission reduces the heat losses of the receiver while the solar power tower runs at a moderate temperature. Therefore, it is feasible to bypass the technological challenges connected with building a high or even super-high temperature receiver. In this temperature range, fewer concentrators and heliostats are required. Each heliostat's efficiency consists of four components: cosine efficiency, shadow and blocking efficiency, reflectivity, and transmission efficiency. Field efficiency equals the average of these four components. Consequently, field efficiency is relatively high, as was the case with Sharafi (2015) [6]. Due to this, both the recipient and field efficiencies of photo-thermal conversion are rather high.

1.3 Aim and Objective

This paper examines solar thermal power generation using a case study of the sea. The goals consist of.

1) To create a grid-connected hybrid generation system mathematical model.
2) To maximise I while minimising costs and increasing power outages.
3) (i) and (ii) have been developed and integrated with particle swamp optimisation.

2. Materials and Method

The following steps are part of the development process:

2.1 Grid-connected hybrid generation system mathematical modelling

According to Figure 1, this study's suggested grid-connected hybrid renewable generating system comprises several parts: solar panels, thermal systems, battery banks, power converters, biogas generators, and diesel generators. When the farm's energy needs cannot be met by renewable generators and utility grid power is unavailable to supplement netload, the diesel generator is kept optional and only utilised as a backup. The first step in enhancing the performance of hybrid systems is the modelling of individual components based on fundamental data from a manual of different manufacturing technology generators, solar radiation data, average wind speed, and farm-accessible biomass resources. The modelling procedure identifies the issue and aids in decision-making while allowing for the recognition and improvement of a scenario. The data is considered to remain constant for an hour while doing the optimisation analysis using renewable energy sources. The following diagram illustrates the various parts of the suggested HRES's mathematical modelling for system performance analysis.

2.2 PV solar

Temperature and solar radiation significantly impact a PV module's performance. The Solar PV array's power output, or P o, may be calculated as:

$$P_o = P_r d_{rf} n_m \left(1 + \alpha\left(T_c - T_{t,stc}\right)\right) \cdot \left(\frac{G_i}{G_{stc}}\right) \quad (1)$$

$$T_c = A_t + \left(\frac{NOCT - 20^0 C}{G_r}\right) \quad (2)$$

where P_r, d_{rf}, nm, α, T_c, $T_{t,}$ STC, G_i, G_{stc}, G_r, A_t and NOCT represent the rated power of the module, the derate factor, the number of PV modules, the temperature coefficient of power for the PV modules, the cell temperature, the cell temperature under standard test conditions (STC), the site's solar irradiance, the solar irradiance under STC, the reference solar irradiance, the ambient temperature, and the nominal operating cell temperature. At STC, reference solar irradiance, and NOCT, the solar irradiance is 1000 W/m2, 800 W/m2, and 4545 O °C, respectively (NARSDA, 2018).

2.3 Diesel power system

Diesel is the fuel for the compression ignition engine that powers the diesel generator. Chemical energy is transformed into electrical energy by the generator. Electricity is produced by combining a diesel engine with an alternator. The size of the generator and the load it is working under will determine how much fuel a diesel generator uses. Most generators run between 80% and 100% of their rated power. The equation might be used to calculate a diesel generator's fuel usage (3). The NARSDA (2018)

$$F_c = AP_o + BP_r \quad (3)$$

where F_c, P_o, P_r, A and B stand for the generator's fuel consumption in litres per kWh, operational power output in kW, power rating in kW, and fuel curve slope in litres per kWh, and fuel curve intercept coefficient in litres per kWh, in that order. Aand B are worth 0.246 and 0.08415, respectively (NARSDA, 2018).

2.4 Power supply

The battery bank's capacity is determined by how long it is anticipated that the battery storage will be able to power the load in the absence of a renewable energy source. These times are also known as days of autonomy. One way to determine battery bank capacity (B c) is as follows:

$$B_c = \frac{L_d D_a}{\eta_r . DoD_{max}} \quad (4)$$

L_d, D_a, η_r, V and DoD_{max} indicate, in that order, the maximum daily load demand, days of autonomy, round-trip battery technology efficiency, system voltage, and a maximum depth of discharge.

2.5 The creation of the optimization strategy

It would help if you determined the decision variables, objective function, and set of constraints to which the process is subject to solve an optimisation issue. The problem's customizable input values are represented by decision variables, the primary function of the problem is represented by the objective function, and restrictions represent the procedure's technical and physical constraints. Costs of energy serve as the study's objective function. Finding the choice factors that minimise costs while observing limitations is the problem. The hybrid energy system's general optimisation model is n variable's objective function maximise/minimise

$$f(x_1, x_2, \dots, x_n) \quad (5)$$

Subject to inequality constraint:

$$g(x) \leq b \quad (6)$$

Subject to equality constraint:

$$h(x) = c \quad (7)$$

Variable bound:

$$x_l \leq x \leq x_u \quad (8)$$

Equation (5) is the objective function subject to constraints given in equations (6) and (7). Equation (8) defines the lower and upper bound of the variables. x_l is the lower bound of the variable, and $x_u$is the upper bound. All vectors that satisfy equations (5), (6) and (7) are known as the feasible solutions out of which the optimum solution for the objective function (5) is determined.

Most practical optimisation problems can be complex and cannot easily be done with traditional techniques. In this study, the techniques of Particle Swamp Optimization (PSO) were used to optimise the hybrid system. The design variables assigned to component capacity are defined in a vector named particle. In other words, each particle represents a certain HRES configuration. After initialising a random particle population, each particle is sent to a simulation module to check its viability.

2.6 The objective function and economic analysis

The objective function of this optimisation problem is to minimise the annualised life cycle system cost (ALCC) in other systems to determine the optimum hybrid system configuration with the lowest energy cost (LCOE). The total system cost includes initial capital (company purchase and installation), replacement costs, costs for operation and maintenance, national grid electricity purchase costs, and system component salvage value throughout the life of the system installed. The system with the lowest cost and meets the constraints is an optimal system. The objective function for optimally designing the HRES is minimised, as stated in equation (9).

$$\min ALCC(₦/yr) = \left[\sum E_j C_j\right] + C_{GRD} \quad (9)$$

Where j is the HRES component indicator, C_j is the unit power cost per year of component$j$, E_j is the total energy produced by component$j$.

$$C_j \in \{C_{PVG}, C_{BGG}, C_{STH}, C_{BAT}, C_{DPG},\}$$

and

$$E_j \in \{E_{PVG}, E_{BGG}, E_{STH}, E_{BAT}, E_{DPG},\}$$

Equation (3.9) can therefore be expanded as:

$$\min LCC = min\,[E_{PVG}C_{PVG} + E_{BGG}C_{BGG} + E_{STH}C_{STH} + E_{DPG}C_{DPG} + C_{GRD}] \quad (10)$$

Where $C_{PVG}, C_{BGG}, C_{STH}, and\ C_{DPG}$ are the annualised unitary energy costs (in /kWh/yr) of the PV, biogas, solar thermal, and diesel power generators? The entire cost of obtaining power from the national grid is C GRD (per year). According to the equation, each component's annualised cost consists of its annualised capital cost, annualised operating and maintenance cost, annualised replacement cost, and annualised salvage value (11).

$$C_j = C_j^{ACAP} + C_j^{AREP} + C_j^{AO\&M} - C_j^{SLV} \quad (3.11)$$

A Where C_j^{ACAP} is the annualised capital cost, C_j^{AREP} is the annualised replacement cost, $C_j^{AO\&M}$ is the annualised operation and maintenance cost, C_j^{SLV} is the salvage value of the technology *j*

2.7 Annualized capital cost

The component's capital cost includes installing and acquiring components. Using the capacity recovery factor (CRF), the yearly capital cost of each component (PV generator, biogas generator, solar thermal, and diesel power) may be computed as follows:

$$C_j^{ACAP} = C_j^{CAP} \times CRF \quad (3.12)$$

Where $C_j^{CAP}$the initial capital cost of technology j, CRF is is the capital recovery factor which is a coefficient to calculate the present value of money. For the component lifetime of n years and interest rate r, the CRF can be determined as thus:

$$CRF(r.n) = \frac{r(1+r)^n}{(1+r)^n - 1} \quad (13)$$

2.8 Annualised replacement cost

Each system component's annualised replacement cost is the cost of replacing the component when it reaches the end of its useful life. The annualised total replacement cost, C_j^{AREP} that took place throughout a project's life may be expressed as follows:

$$C_j^{AREP} = C_j^{REP} \times \frac{1}{(1+r)^y} \times CRF \quad (14)$$

Where $_y$ is the component's lifespan in years, and C_j^{REP} is the component's replacement cost. Replacements are necessary if the component lifespan is longer than the project lifetime. The lifespan of a biogas or diesel generator is its number of operating hours. The life of biogas, measured in years (N_{BGG}^{LS}) and diesel generator (N_{DPG}^{LS}), can be calculated as expressed in equations (15) and (16), respectively.

$$N_{BGG}^{LS} = \frac{N_{BGG}^{h}}{N_{BGG}^{h/y}} \quad (15)$$

$$N_{DPG}^{LS} = \frac{N_{DPG}^{h}}{N_{DPG}^{h/y}} \quad (16)$$

N_{BGG}^{h} and N_{DPG}^{h} are biogas and diesel generator lifetime (hours). N_{BGG}^{h} and N_{DPG}^{h} is the number of hours of operation in a year for biogas and diesel generator, respectively.

2.9 Annualized maintenance cost

The maintenance cost of component (C MJ) includes labour costs, repair and other charges and can be expressed as in equation (17)

$$C_j^{m} = N_j C_j^{m/h} \times \frac{1}{(1+r)^y} \times CRF \quad (3.17)$$

A Where N_j is the hours of the running of component *j* and $C^{MJ/h}$ is the hourly maintenance cost of component *j*.

2.10 Annualised fuel cost

In the case of a diesel generator, the fuel cost is determined by multiplying the amount of diesel the generator used over a year (in litres) by the diesel price (in /ltrs). The total cost of fuel used (C_{DPG}^{f}) can be calculated as

$$C_{DPG}^{f} = E_{DPG}C_f F(t) \times \frac{1}{(1+r)^y} \times CRF \quad (3.18)$$

E_{DEG} is the total energy generated by the diesel engine generator in (kWh/yr). C_f is the unit price of diesel $(₦/ltrs)$, and $F(t)$ is the rate at which the diesel generator consumes fuel in litres/kWh.

2.11 Salvage value

This is the estimated resale value of a component at the end of the project life. The salvage value of a component *j* (C_j^{SLV}) can be calculated as a fraction of the placement cost, as shown in equation (3.19) below.

$$C_j^{SLV} = C_j^{REP} \frac{N_j^{Rem\_LS}}{N_j^{LS}} \times \frac{1}{(1+r)^y} \times CRF \quad (19)$$

Where $C_j^{REP}$the replacement cost of the component j is, $N_j^{Rem\_LS}$ is the remaining life (in years) of component *j*, and N_j^{LS} is the total life span (in years) of component *j*.

2.12 Grid purchase cost

Aside from the relevant components, another significant economic factor in grid-connected systems is the cost of power exchange between the hybrid system and the utility grid. The planned HRES will purchase only grid electricity. The equation represents the entire amount of electricity purchased from the grid, E GRD (20)

$$E_{GRD} = \sum_0^{8760} P_{GRD}(t) \times \frac{1}{(1+r)^y} \times CRF \quad (20)$$

Therefore, the total price of electricity purchased from the grid in a year (C_{GRD}) can be expressed as equation (21)

$$C_{GRD} = E_{GRD}\, C_{GRD}^{/kWh} \quad (21)$$

Where $C_{GRD}^{/kWh}$ is the unit cost of electricity (₦/kWh) purchased from the grid?

2.13 Levelised cost of electricity (LCOE)

The cost per kWh of the system's actual power produced during a predetermined life or duty cycle is represented by the term "LCOE." The value enables scale-free comparison of various energy system configurations. For instance, the initial capital cost of a solar PV system might be higher than that of a diesel generator but levelized over the following 25 to 30 years (depending on how long the system is expected to operate), and the operation and maintenance cost of solar PV is relatively very low in comparison to a diesel generator. LCOE is defined as the ratio of the system's average annual energy production during its lifespan to the total lifetime cost of the system (LCC).

$E_{ann\_lifetime}$.

$$LCOE(₦/kWh) = \frac{ALCC\ (₦/yr)}{E_{ann\_lifetime}\ (kWh/yr)} \quad (22)$$

2.14 Constraints

In order to provide workable solutions, the optimisation issue would be subject to practical or technological limitations. The first limitation is the energy balance between the supply section and the load at each moment. Equation-based expression (23).

$$E_{PVG,load}(t) + E_{BGG,load}(t) + E_{BAT,load}(t) = E_{Load-Total}(t) \quad (23)$$

According to Equation 24, the energy created by or added to each component at any given moment should be equal to or less than that component's capacity;

$$E_j(t) \leq P_j \times \Delta t \quad (24)$$

where Δt is the length of time regarded as one hour.

In order to prolong the battery life cycle, there is an upper and lower limit for the state of charge that batteries may be in (Equation (25)).

$$SOC_{min} \leq SOC(t) \leq SOC_{max} \quad (25)$$

The operating range of a diesel generator must fall between the lowest and maximum permitted values. Diesel generator efficiency is low at light load. Hence it should only be used at levels exceeding 70% of its rated capacity.

$$P_{minj} \leq P_j \leq P_{max,j} \quad (26)$$

The non-negativity restrictions for choice variables and energy flow, as well as the upper bound for decision variables, are represented by Equation (27).

$$P_j(t) \geq 0 \quad (27)$$

2.15 Particle Swarm Optimization

James Kennedy, a social psychologist, and Russell Eberhart, an electrical engineer, first suggested the meta-heuristic optimisation approach known as particle swarm optimisation (PSO) in 1995. It is based on the social navigation or foraging of a flock of birds or fish school. The PSO method may resolve binary or discrete and continuous issues. The initial generation of a particle population (or swarm) is random. PSO's particles all fly in the search space at constantly changing speeds based on their own flying experience (value) and that of their neighbours (value). A vector that specifies the swarm's speed in each direction serves as the basis for particle motion. The best particle is the one that has been found to date for each problem and is kept in memory.

Additionally, the global best particle is the result that has been made among all particles to date (Gbest). Based on each particle's experience and the best estimate for the entire population, the speed and position of each particle are updated. The effectiveness of PSO depends on the particles in the swarms exchanging information about one other, enabling the particles to migrate into better regions and eventually converge to the optimal global location.

The initial random number of particles or the population is first created with random position vectors (Xit) and velocity (Vit).

Each starting population particle's fitness value is determined to evaluate its position. It is then compared to its best experience from the past, and the personal best fitness values are compared to find the overall best value. A particle's experience is updated with the new value if it is better than the best prior value achieved (higher for maximisation problems and lower for minimisation problems); the experience is kept untouched. Additionally, the particle's velocity is modified by its own best experience (Post) and the best particle globally (Gbest). In actuality, particles in each iteration migrate toward the finest global particle. The top global particle is updated at the end. Figure 1 shows a vector diagram illustrating the dynamics of particles in PSO.

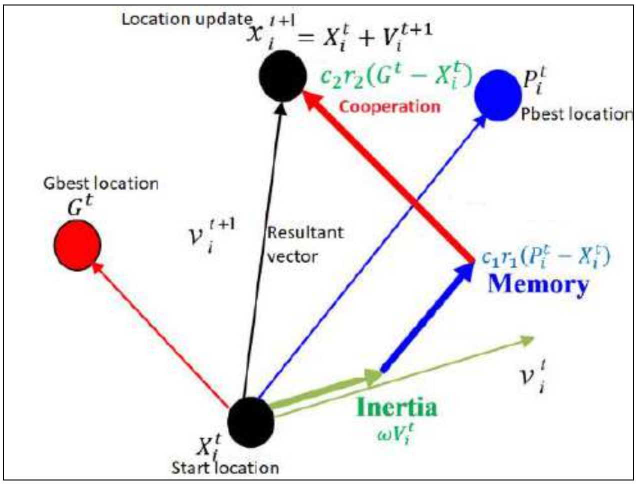

Fig 1: Dynamic of particles in PSO

The following equations can modify the velocity and position of each particle. Utilising the following information,

Each particle seeks to change its location. (X_i^t).

Their present locations. (V_i^t)) are their current velocities.

The separation between the athlete's current standing and their personal best, or Pbest (P_i^t).

The gap between the present position and the global best, or Gbest, is measured in terms of$(G \quad T)$.

The following equations can change each particle's location and velocity.

$$X_i^{t+1} = X_i^t + V_i^{t+1} \tag{28}$$

$$V_i^{t+1} = \omega V_i^t + c_1r_1(P_i^t - X_i^t) + c_2r_2(G^t - X_i^t) \tag{29}$$

Where: X_i^{t+1} is the position of a particle in the next iteration, X_i^t is the current position of a particle, V_i^{t+1} is the velocity for the next iteration, ω is inertia weight or inertia coefficient, c_1 and c_2 are the acceleration factor (weights) for the cognitive and social factors respectively, r_1 and r_2 are two uniform random number between 0 and 1. and are used to maintain the diversity of the population.

As seen from equation (29), there are three terms to update the velocity; The first term, ωV_i^t, is known as the Inertia velocity factor and is used to incorporate the previous velocity and prevent the sudden change of the particle velocity. This vector component is why particles broadly are biased to keep the direction that they have been moving on. The second term $c_1r_1(P_i^t - X_i^t)$ is called the cognitive component or individual component and denotes how much confidence the particle has in itself. While the last term, $c_2r_2(G^t - X_i^t)$ denoted how much confidence the particle has in the swarm.

It is well recognised that it has a social element. Each particle moves during the initial iteration toward its individual and collective optimal location. After updating the velocities and coordinates for the following iteration step (t + 1), the parameters are finished. Repetition of this method continues until a predetermined stopping requirement is satisfied. The maximum number of iterations, a determined difference in the value of the objective function's fitness function across consecutive iterations, or the average value of the whole population of particles can all serve as halting criteria. The PSO method is seen in Figure 2 and as described above.

The population size, c_1, and c_2 are the PSO algorithm's three most crucial parameters. Exogenous parameters are those that users must initialise before an execution. The parameters' ideal value relies on the problem that has to be solved. The literature recommends the following interval for establishing PSO parameters:

- A big inertia weight (ω) makes it easier to do a global search, whereas a small one makes it easier to conduct a local search. The highest PSO performance is achieved by progressively lowering the inertia weight from a reasonably big number to a small value throughout the PSO run instead of using constant inertia weight settings.
- Acceleration factor (c_1,c_2): Typically, an equal value of c_1 and c_2 within the range 0 to 4 recommended
- Population size: depending on the problem search space, the population size can be in the range of 20 to 60 particles

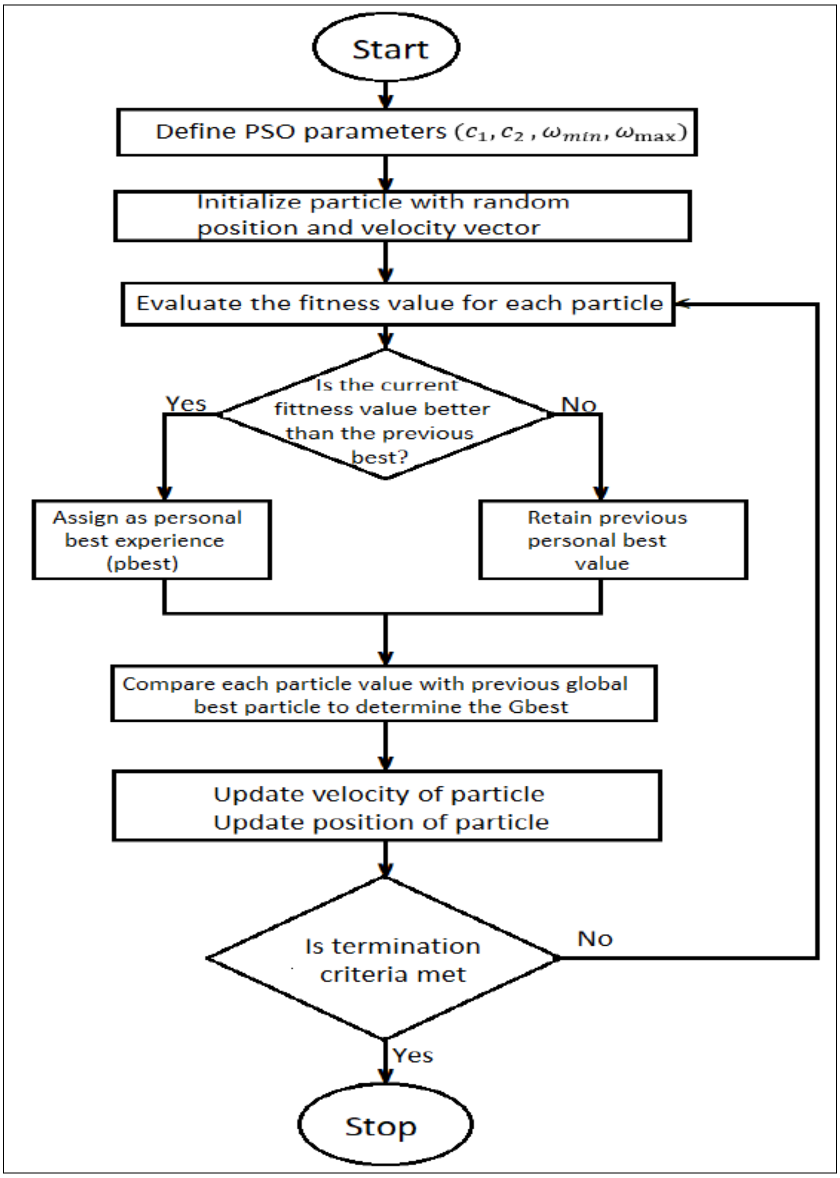

Fig 2: Chart of Proposed PSO Algorithm

3. Results and Discussion

According to the outcomes of using PSO, TAC is $38,643, and the Levelized cost of energy (LCOE) for the ideal PSO size is 0568, as shown in Table 1. Table 1 displays the cost analysis of the various parts that make up the system. Figure 3 depicts the algorithm's convergence and global best selection plot (PSO). Figure 4 depicts a weekly plot of the relationship between community load, battery charge, and solar energy. In contrast, this depicts a weekly plot of the link between community load demand, battery charge, and solar energy supplied.

Table 1: Comparative result of the optimal sizing

Parameter	Particle Swarm Optimization (PSO)
Number of Solar PV Required (kW)	426
Number of Battery Units	45
Minimum Total Diesel size Required (kW)	163.2895
Total load of the community (kWh)	680,850
Battery In (Charge)	496,720
Battery Out (Discharge)	430,600
Total Annualized Cost ($/ **yr**)	38,643
LCOE ($/ kWh)	0.0568

Table 2: Cost analysis of the various components

Parameter	Particle Swarm Optimization (PSO)
Total Solar Cost ($)	12,006
Diesel Generator Cost ($)	735.6914
Total Battery cost ($)	8638.90

Power Inverter Cost ($)	17,262

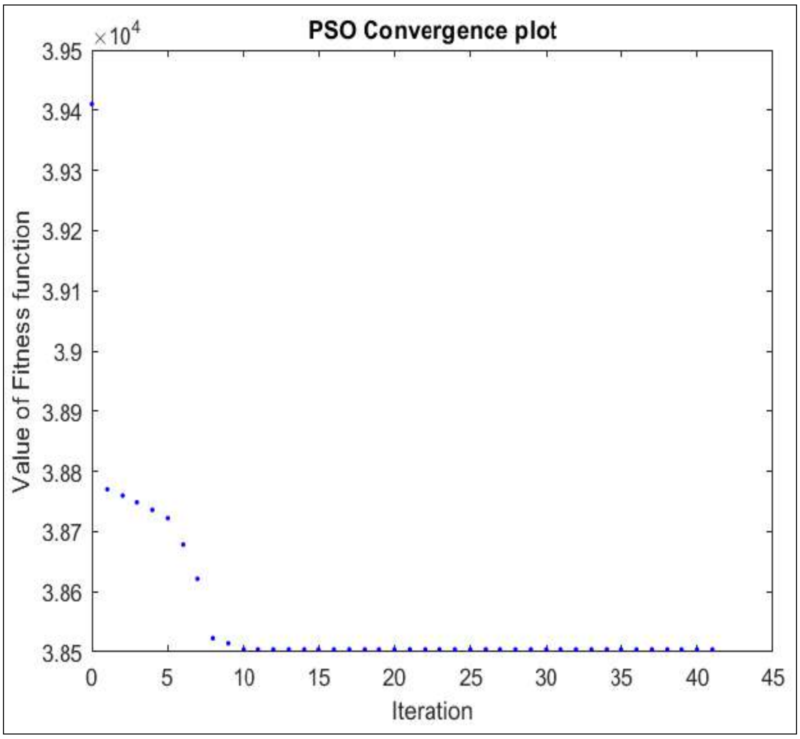

Fig 3: Convergence plot of PSO.

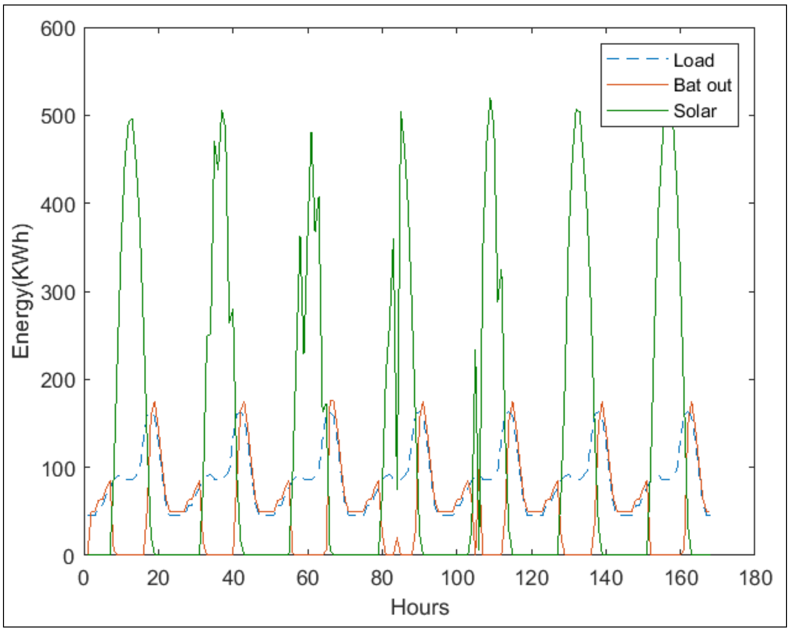

Fig 4: A weekly chart showing the relationship between load, battery charge, and the amount of solar energy that is produced

4. Conclusion and Recommendation

This research analyses solar thermal power output using mathematical modelling of grid-connected hybrid generating systems. Next, the parameters of the PSO algorithm were set, and the method's fundamental principles were implemented. ABC, PSO, and GA were used to best scale the system utilising the proposed sizing method. Utilizing hourly temperature (ambient) data and yearly solar radiation acquired from a reliable source online, the optimal size is determined for the Ile-Oluji village. The procedure was executed using the gathered load profile from the community, and the output reveals that PSO is highly effective in comparison to the simulation results.

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