Sustainable Energy Technologies and Assessments 53 (2022) 102662

Contents lists available at ScienceDirect

Sustainable Energy Technologies and Assessments

journal homepage: www.elsevier.com/locate/seta

Optimization based on tabu search algorithm for optimal sizing of hybrid PV/energy storage system: Effects of tabu search parameters

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ARTICLE INFO

Keywords:
Hybrid system
PV-battery system
Low-cost green electricity
Optimal sizing
Tabu search algorithm
Optimization parameters

ABSTRACT

The hybrid photovoltaic/battery energy storage system is a relevant pathway to generate low-cost green electricity. In the literature, cost optimization of these systems has been extensively used. However, the unpredictability of model and optimization methods input information, present the most drawbacks of optimal sizing of the system. Herein, an optimal sizing and evaluation framework are presented for an off-grid clean microgrid system solar/battery energy storage, to generate low-cost green electricity of rural building in China. The optimal sizing of the system is based on the hourly meteorological data and load demand during a year; with the lowest total life cycle cost as the objective function and the maximum reliability. A novel *meta*-heuristic tabu search algorithm is used in the solution process to obtain the optimal sizing of the system in terms of economics and reliability. Additionally, the variations of the optimal sizing of the system on the basis of different types of reliability index and tabu search parameters, such as initial solutions, neighborhood structure, number of run and iteration, is further comprehensively evaluated and investigated. The results prove that it is easier to find the optimal decision variables for the clean microgrid system with the optimal parameters of the algorithm.

Introduction

Fossil fuels are significant energy generation sources in many countries, especially in remote areas. Due to further increase in energy prices, increase in the average global surface temperature and environmental pollution, fossil fuels are not favourable [1,2]. Among the fossil fuels, coal-fired electricity generation was claimed to release the most amount of environmental pollution. China has been accelerating its efforts to reduce environmental pollution, especially carbon dioxide emissions, and transform its energy structure [3,4]. In this regard, the use of renewable energy to produce green energy will be an essential step for decarbonisation in the future .[5,6]

That is to say, the use of renewable energy, especially solar energy, is a key solution in to generate low-cost green electricity in remote areas [7,8]. So, solar photovoltaic (PV) technology has been gradually widely used to the household [9–11]. In this regard, to eliminate the intermittency effects of solar energy system, use of the energy storage (ES) structure is a key solution [12,13]. Battery is one of the best ES in solar structure. As a result, hybrid solar energy systems with energy storage are essential to increase reliability in remote rural areas, and the use of hybrid solar energy systems can effectively improve the users' energy economy [14,15]. To ensure the cost-effective and stability, the optimal planning, design, and sizing of the system based on the PV and energy storage capacity is critical [16]. So an efficient algorithm and model for optimization is necessary [17–22]. For this aim, some researchers investigated hybrid systems with battery storage.

Qi et al. [23] reviewed the application of off-grid solar/wind/diesel hybrid systems consisting of battery ES system (BESS) to covering the load of an island in China. It is found that that the hybrid system can decrease the cost of energy and environmental pollution for the island. Bayod-Rújula et al. [24] studied the influence of size of the batteries on on-grid hybrid wind-PV system with BESS to supply of the demand of a typical residential energy in Spain. Sinha and Chandel [25] determined the optimal design of PV-wind structure with BEES for 12 low windy

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https://doi.org/10.1016/j.seta.2022.102662
Received 15 July 2022; Received in revised form 12 August 2022; Accepted 15 August 2022
Available online 5 September 2022
2213-1388/

sites in India. They found that the micro-wind turbine (1 kW) is suitable for these sites for a classic load. Aissou et al. [26] presented a simple model of the hybrid solar/wind power structure with BESS for supplying a load in Algeria. Mahmood et al. [27] suggested a power management strategy for solar structures with BESS in remote areas. Kusakana [28] modeled a nonstop control strategy hybrid solar–diesel structure with BESS to minimize the total cost of the structure under technical conditions. Its show that using the hybrid structure, significant fuel saving can be reached compared to the DG. Rodríguez-Gallegos et al. [29] presented a technique to define the sizing and siting of the off-grid solar/diesel with BESS using the PSO algorithm to reduce the total cost in Indonesian island. They reveal that the hybrid system yields the lowest cost to fulfilling the load demand. Gholami et al. [30] presented a technique for optimum battery storage sizing with wind speed data in a hybrid structure with BESS. Souza Rocha et al. [31] presented multi-objective optimization method to the planning of the wind-PV system with BESS in Brazil. Mazzeo et al. [32] presented a technique based on energy reliability for the optimization of an on-grid and off-grid solar-wind system with and without BESS. Moradi et al. [33] presented a method to minimize hybrid systems operation and maintenance costs. Also, the BESS role in the hybrid systems performance and cost saving application was considered. Yu et al. [34] presented a process based on adaptive Predators to optimal configuration of a solar/diesel structure with BESS to refine the load demand of an isolated part in Hoxtolgay, China. Li et al. [35] presented a techno-economic feasibility of wind/solar structure with BESS to supply the demand of a household in Urumqi, China by HOMER software. In Amara et al. [36], a techno-economic optimization of a micro-grid solar/wind/battery/diesel structure is presented to reduce the cost and satisfy the reliability level essential by customers. In this study a robust energy management with a recursive algorithm are used at covering the load demand. Xia et al. [37] used a stochastic model with a hybrid solution approach to size ES system for power grid planning with intermittent wind generation. Zolfaghari et al. [38] suggested a cost model to determine the optimal size of a BESS to reduce the operational costs of Microgrids. Khawaja et al. [39] presented an energy management strategy to determine the best size of a PV/diesel/fuel cell structure. Ayop et al. [40] presented the review of the Microgrid to determine the optimal size for the stand-alone PV structure using the iterative technique. Kumar et al. [41] proposed a wolf optimizer algorithm for effective designing of hybrid MG with solar/wind and battery and fuel cell systems at test locations. Yoza et al. [42] used a Tabu search (TS) algorithm to optimal capacity and planning of photovoltaic generation and battery in smart house. Han et al. [43] presented a Tabu search algorithm for wind power prediction model using forecast load. It is found that the TS algorithm is a kind of intelligent method that can attain the global optimizations. Katsigiannis et al. [44] proposed a metaheuristic technique with TS for optimal sizing of small independent power structures in remote locations. Zhang et al. [45] presented a Tabu search technique for optimization of a solar/wind/BESS stand-alone structure with forecast load. They reveal that the TS earnings more hopeful results than the other method. So, it is quite essential to use more innovative optimization methods to define the optimal sizing and evaluation framework within the clean microgrid system to generate low-cost green electricity.

In this study, determination of the optimal sizing of hybrid PV/BESS for an isolated rural area is considered as optimization problem. Because of the uncertainty of input information in modeling in the evaluation process, the hourly meteorological data and load demand during a year are used. Also, due to the uncertainty or unpredictability of input information in optimization methods, a novel *meta*-heuristic tabu search algorithm is proposed. Within the proposed algorithm, the weights of important and influential parameters are firstly obtained via past calculations and reviews on optimization problems. After determination of the weight of influential parameters, alternative parameters are evaluated by novel *meta*-heuristic optimization algorithm. This method provides the possibility for decision makers to find the exact weight of the influencing parameters of the algorithm in optimization problems. In this way, the uncertainty caused by the input parameters of the algorithm in optimization problems will be significantly reduced. The main contributions of the study are as follows:

- An optimal sizing and evaluation framework are presented for an off-grid clean microgrid system solar/battery energy storage, to generate low-cost green electricity of rural building in China.
- The optimal sizing of the structure is based on the hourly meteorological data and load demand during a year; with the lowest life cycle cost as the objective function and the maximum reliability.
- A novel *meta*-heuristic tabu search algorithm is proposed in the solution process to obtain the optimal sizing of the structure in terms of economics and reliability.
- The variations of the optimal sizing of the structure on the basis of different types of reliability index is investigated
- The tabu search parameters, such as initial solutions, neighborhood structure, number of run and iteration, is comprehensively evaluated and investigated in optimization problems.

The rest of the study is prepared as follows: The system description explained in the second section. The proposed optimization model and *meta*-heuristic tabu search algorithm described in the third and fourth units. Then, results and conclusion are presented in the fifth and sixth units.

System description

Schematic diagram of modeling and optimizing a hybrid system to provide a cost-effective and reliable load of a rural building in China is shown in Fig. 1.

The schematic diagram of the off-grid clean microgrid system is shown in Fig. 2, which including PV panels, battery energy storage system (BESS), inverters, and household loads. Fig. 2 shows an overview of the household load demand data.

In the off-grid clean microgrid system, the PV systems provide the main energy, and the excess energy will charge the BESS while the BESS will discharge when the PV system generation is insufficient.

PV system

The power of solar panels is related to the solar radiation (S), ambient temperature (T_{air}) and the characteristics of the solar panels. Fig. 2 shows an overview of the S and T_{air} data. The power output of each solar panel can be calculated as follows [12,45]:

$$P_{PV} = N_{PV} \times \eta_{inv} \times \left(P_R^{PV} \times \frac{S}{1000} \times [1 - \alpha((T_{air} + \beta \times S) - 25)] \right) \tag{1}$$

Here, N_{PV} is the number solar panels, P_R^{PV} is the rated power of the solar panel at standard operating conditions, S is solar radiation, T_{air} is the ambient temperature, α (3.7×10^{-3}) and β (3×10^{-2}) are fixed numbers in polycrystalline PV panels, which is used in this article η_{inv} is the inverter efficiency, and the PV panel total capital cost is $614.

Bess

The lead-acid type of BESS is proposed to store surplus energy produced by PV system to increase the reliability of the scheme. The state of charge (SOC), as an important parameter in BESS, will be expressed as [12,45]:

$$SOC(t) = \frac{C_{BESS}(t)}{TC_{BESS}} \tag{2}$$

Here, TC is the total capacity of BESS and $C_{BESS}(t)$ is the BESS capacity at each time.

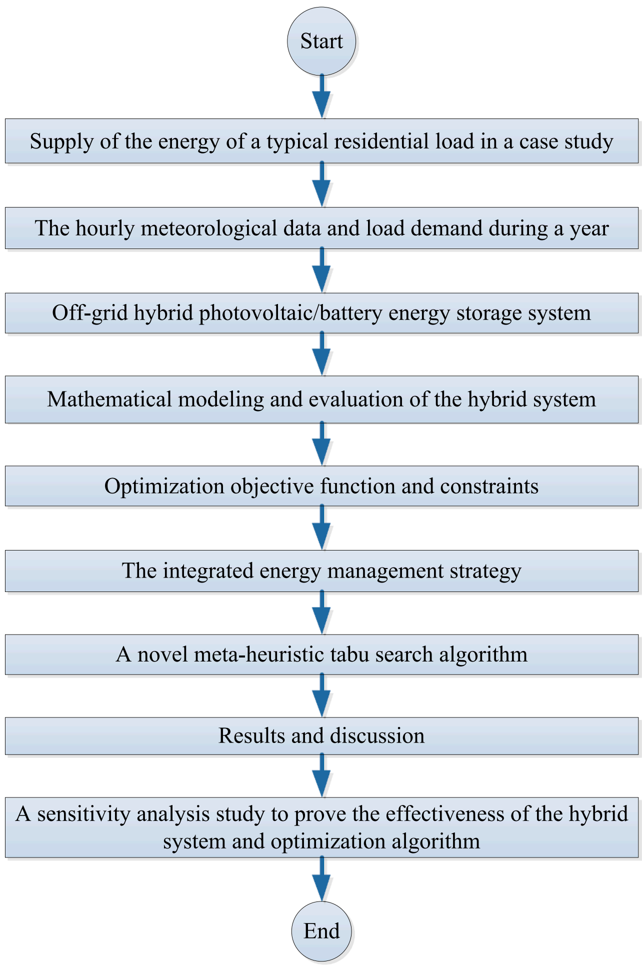

Fig. 1. Modeling and optimizing a hybrid system diagram.

When the PV system generation is greater than the load demand, the charging state of BESS can be calculated as follows:

$$SOC(t) = SOC(t-1)\cdot(1-\sigma) + \eta_{BC} \times \left[P_{PV}(t) - \frac{P_{Load}(t)}{\eta_{Inv}}\right] \times \Delta t \tag{3}$$

When the PV power generation is less than the load demanded, the discharging state of BESS can be calculated as follows:

$$SOC(t) = SOC(t-1)\cdot(1-\sigma) - \left(\frac{\left[\frac{P_{Load}(t)}{\eta_{Inv}} - P_{PV}(t)\right]}{\eta_{BDC}}\right) \times \Delta t \tag{4}$$

where P_{Load} is the load demand, σ is the self-discharge efficiency (here 0.02 %), η_{BC}, and η_{BDC} are the charging and discharging efficiency, and unit cost of battery is $130.

Optimization model

The objective of this study is to determine the optimal decision variables (number of BESS (N_{BESS}) and the number of photovoltaic panels (N_{PV})) for an off-grid clean microgrid solar -energy storage system used to generate low-cost green electricity of rural building in China such that the total life cycle cost of the microgrid is minimized while satisfying the reliability constraint.

Objective function

The total life cycle cost (TLCC) is identified as the objective function in this study, and the optimization is aimed at minimizing its cost. The total LCC cost is the sum of the total annual investment (AI), replacement (AR), and O&M cost (AM) of components, which is expressed as follows:

$$TLCC = AI + AR + AM \tag{5}$$

$$AI = ATF \times \left(N_{PV} \times C_I^{PV} + N_{BESS} \times C_I^{BESS} + N_{inv} \times C_I^{inv}\right) \tag{6}$$

$$ATF = \frac{IR\cdot(1+IR)^n}{(1+IR)^n - 1} \tag{7}$$

$$AR = C_R^{BESS} \times N_{BESS}\cdot \sum_{m=5,10,15} \frac{1}{(1+IR)^m} + C_R^{inv} \times N_{inv}\cdot\left(\frac{1}{(1+IR)^{10}}\right) \tag{8}$$

$$AM = N_{PV} \times C_M^{PV} + N_{BESS} \times C_M^{BESS} + N_{inv} \times C_M^{inv} \tag{9}$$

where C_I the unit investment cost of components, *IR* (here 5 %) is the interest rate, C_R is replacement cost per unit for components, C_M is the

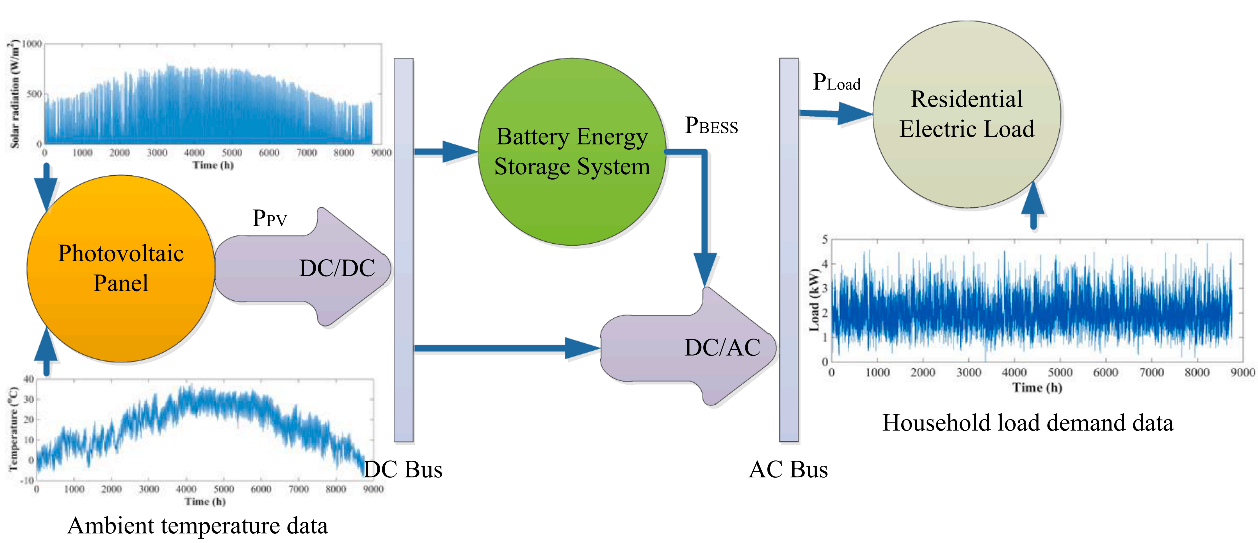

Fig. 2. Off-grid clean microgrid system diagram.

annual operation and maintenance cost per unit for components, and n (here 20 years) is system life span.

Reliability index and constraints of the problem

The loss of energy supply probability is proposed as the reliability index (RI) in this study. The RI is expressed as follows:

$$RI = \frac{\sum_{t=1}^{8760}\left(\frac{P_{Load}(t)}{\eta_{Inv}} - P_{PV}(t)\right)\cdot\Delta t}{\sum_{t=1}^{8760} P_{Load}(t)\cdot\Delta t} \tag{10}$$

In order to have a reliable power supply during the off-grid clean microgrid solar -energy storage system, the optimization process must define a RI_{max} to respond to the load.

$$RI \leqslant RI_{\max} \tag{11}$$

Some of the constraints of the optimization problem are as follows:

$$0 \leqslant N_{PV} \leqslant N_{PV}^{max} \tag{12}$$

$$0 \leqslant N_{BESS} \leqslant N_{BESS}^{max} \tag{13}$$

$$SOC^{\min} \leqslant SOC \leqslant SOC^{\max} \tag{14}$$

$$SOC^{\min} = (1 - DOD)\cdot\lambda \tag{15}$$

where *DOD* is depth of discharge *and* λ is the nominal capacity of BESS.

Meta-heuristic tabu search algorithm

The TS is a metaheuristic search technique using local search approaches used for mathematical optimization. It was first created by Glover [46].

The novel *meta*-heuristic TS algorithm (MTSA) is made use to obtain the optimal sizing of the off-grid clean microgrid structure with solar and energy storage unites. The *meta*-heuristic tabu search algorithm implementation process for optimal configuration design of is shown in Fig. 3.

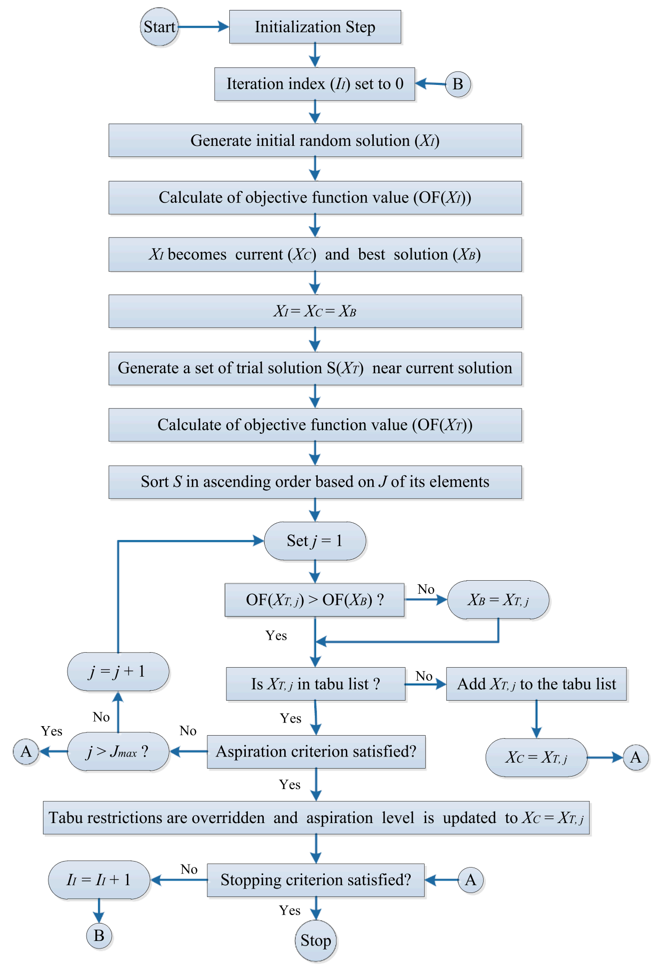

Fig. 3. Meta-heuristic tabu search algorithm diagram.

Results and discussion

In this paper, the MTSA algorithm is used to solve the optimal configuration of an off-grid clean microgrid solar -energy storage structure to solve a reliable power supply problem. In basic mode, the trial solutions and neighborhood factor are set to 30 and 10, and the maximum number of iterations and number of runs are set to 100 and 30, and the benchmark RI_{max} is set at 2 %.

The results obtained when the above data and the optimization model were applied show that the optimal number of PV and BESS are 59 and 3712 units and the optimal TLCC and RI are $114,884 and 1.9462 %. So the mean TLCC is $ 379,024 and mean simulation time is 2.3354 *sec*. The results show that under this case, the LCC of PV system is $2907 and the LCC of BESS is $111,459.

Sensitivity analysis

In this subsection, some important techno-economic parameter variations, reliability index, and tabu search parameters, such as initial solution or trial solutions, neighborhood structure, number of run, and the number of iteration are further investigated. The performance of an off-grid clean microgrid solar -BESS with different reliability types under different important parameters of algorithm will be explored simultaneously, so as to provide a complete reference for algorithm and selecting a more economical and reliable clean microgrid hybrid system under different scenarios. When exploring each important parameter variation, it is ensured that the other parameters are constant.

Evaluation of reliability index variations

It is essential to evaluate the influence of different reliability index variations on the cost effectiveness of clean microgrid hybrid energy system. Defining suitable reliability index will support the development of the clean microgrid hybrid energy system and decrease unnecessarily high investments. As a results, the optimal configurations of the an off-grid clean microgrid solar -energy storage system considering reliability index sizes of 0 %, 1 %, 2 % (baseline), 5 %, and 7 % are presented. In this regard, the other parameters are constant, and the results of optimal configuration of the system are given in Table 1. So, the Min.TLCC worth of the clean microgrid system is decreasing while the RI is increasing and the number of BESS and PV is decreasing as the rate continues to increase. As a result, the reliability of the power supply is reducing. Specifically, as the RI increases from 0 % to 7 %, the Min.TLCC of clean microgrid system is $253,676, $118,266, $114,884, $62,447, and $57,053, respectively. The mean of TLCC value decreased from $452,844 to $344,376 and the RI increased from 0 to 5.9264 %. The

Table 1
Results of optimal configuration variations of off-grid clean microgrid system under different RI_{max} scenarios.

RI_{max} (%)	N_{PV}	N_{BESS}	Min.TLCC ($)	Mean. TLCC ($)	Mean.ST (*sec*)	RI (%)
0	61	8331	253,676	452,844	2.3109	0
1	60	3823	118,266	407,507	2.3234	0.8007
2	59	3712	114,884	379,024	2.3354	1.9462
5	60	1964	62,447	375,703	2.3177	4.3393
7	59	1786	57,053	344,376	2.3521	5.9264

number of BESS decreased from 8331to 1786 and the number of PV panel decreased from 61 to 59. So, investors in clean microgrid to produce electrical energy should define an acceptable reliability index to avoid unreasonable capital investment.

Evaluation of trial solutions variations

Investigation and analysis of the performance variation of the off-grid clean microgrid structure by adjusting the trial solution of the algorithm while keeping other parameters constant are presented. The proposed optimization algorithm starts with a random initial solution. It finds neighbors of the current solution called trial solutions. The trial solution of the algorithm is one of the important parameters in finding the optimal solution and its changes have a great impact on the final solution. As a result, the role of the trial solution has an essential impact on the stability of the whole clean microgrid system. Results of optimal configuration variations of off-grid clean microgrid system at 10, 20, 30 (baseline), 40, 50, 60, 70 and 100 trial solutions are presented in Table 2. So, the clean microgrid system at 10 to 100 trial solutions shows an increasing trend of mean simulation time and decreasing trend of Min.TLCC, which implies a decrease in number of BESS and an increase in number of solar panel. In general, a uniform trend is not observed in the results, and this is due to the random search of the algorithm. In this regard, it can be seen that when trial solutions is equal to 100, the best results will be obtained.

Evaluation of neighborhood factor variations

The proposed TS algorithm is a robust neighborhood search method used to solve an extensive kind of optimization problems. As a result, the number of neighbourhood factor will have a great effect on the optimal results of the clean microgrid structure. And finding the optimal number of neighbourhood factor is a challenge and very necessary to get optimal results. In this section, the neighborhood factor is set at 1, 5, 10 (baseline), 15, 20, 25, 30, 40, and 50, respectively, and the optimal configuration variations of off-grid clean microgrid system shown in Table 3. It can be seen that the clean microgrid system at 1 to 50 neighborhood factors shows a decreasing trend of Mean TLCC value and decreasing trend of Min.TLCC, which denotes a decrease in number of BESS and an increase in number of solar panel. It also shows little variation on the mean simulation time. So, it can be seen that when number of neighbourhood factors is equal to 40, the best results will be obtained.

Evaluation of number of iteration variations

The number of iterations is one of the important limitations of any optimization process. And choosing it correctly can have a great impact on obtaining the optimal result. In this section, the number of iteration is set at 20 to 100 (baseline), and 100 to 1000, respectively, and the optimized results of off-grid clean microgrid system are presented in Table 4. It is found that the Min.TLCC and Mean. TLCC of the off-grid clean microgrid system are decreasing as the number of iteration rises and the Mean. ST value is gradually increasing, and the RI value of the system is also increasing from 1.2232 % to 1.9367 %. This indicates that the Min.TLCC and Mean. TLCC of the off-grid clean microgrid system is increasing due to the decrease in number of iteration from 100 to 20, despite the fact that the Mean. ST is also decreasing. In this regards, due to the increase in number of iteration from 100 to 400, the Min.TLCC of the off-grid clean microgrid system is decreasing from $114,884 to $58,910. It can be seen that after 400 iterations, the optimal results are constant and only mean of TLCC decreases and mean of ST increases. It can be concluded that the number of iterations of 400 is the most suitable for optimization of the off-grid clean microgrid system.

Evaluation of number of run variations

The number of run of an optimization algorithm directly affects the optimal results of the hybrid system. In other words, a small number will lead to a more unstable result and a larger number will lead to an increase in the calculation cost. This section attempts to further investigate the number of run variations of optimization algorithm, which in turn allows the analysis of the optimal configuration of clean microgrid system performance variation under different number of run. The results of optimal configuration variations of off-grid clean microgrid system under different number of run scenarios are presented in Table 5.

It is found that the Min.TLCC of the off-grid clean microgrid system is decreasing from $520,621 to $58,910 as the number of run rises and the Mean. TLCC value is gradually decreasing from $520,621 to $399,022, and the RI value of the system is also increasing from 1.5584 % to 1.9367 %. This indicates that the Min.TLCC and Mean. TLCC of the off-grid clean microgrid system is decreasing due to the increase in number of run from 1 to 200. In this regards, due to the increase in number of run from 1 to 50, the Min.TLCC of the off-grid clean microgrid system is decreasing from $520,621to $58,910. It can be seen that after 50 runs, the optimal results are constant. It can be concluded that the number of runs of 50 is the most suitable for optimization of the off-grid clean microgrid system.

Finally, it can be seen that when trial solutions is equal to 100, neighbourhood factors is equal to 40, number of iterations is equal to 400, number of runs is equal to 50, the best results will be obtained. The results obtained when the above optimal data (RI_{max} is equal to 2 %, trial solutions is equal to 100, neighbourhood factors is equal to 40, number of iterations is equal to 400, number of runs is equal to 50) and the

Table 2
Results of optimal configuration variations of off-grid clean microgrid system under different trial solution scenarios.

Trial solutions	N_{PV}	N_{BESS}	Min.TLCC ($)	Mean. TLCC ($)	Mean.ST (*sec*)	RI (%)
10	60	3445	106,916	442,841	0.9281	1.3083
20	59	4568	140,587	394,310	1.5969	1.3038
30	59	3712	114,884	379,024	2.3354	1.9462
40	61	2629	82,637	397,778	2.9713	1.7070
50	60	3263	101,451	412,755	3.6531	1.6335
60	62	2974	92,872	393,707	4.3870	0.5790
70	59	3810	117,826	357,879	5.0219	1.7675
100	63	2131	67,609	331,299	7.2286	1.9113

Table 3
Results of optimal configuration variations of off-grid clean microgrid system under different neighborhood factor scenarios.

Neighborhood factor	N_{PV}	N_{BESS}	Min. TLCC ($)	Mean. TLCC ($)	Mean. ST (*sec*)	RI (%)
1	59	4128	127,375	381,498	2.3510	1.4941
5	58	6145	187,889	436,694	2.2552	1.4334
10	59	3712	114,884	379,024	2.3354	1.9462
15	59	5805	177,730	422,501	2.3167	0.7539
20	60	3779	116,945	376,909	2.3031	0.8187
25	61	2564	80,511	385,662	2.3151	1.8374
30	61	2910	90,901	355,869	2.3369	1.1254
40	65	1838	58,910	358,860	2.3844	1.9367
50	65	1840	58,969	328,920	2.3429	1.9330

Table 4
Results of optimal configuration variations of off-grid clean microgrid system under different number of iteration scenarios.

Number of iteration	N_{PV}	N_{BESS}	Min.TLCC ($)	Mean. TLCC ($)	Mean.ST (*sec*)	RI (%)
20	60	3503	108,658	415,176	0.4578	1.2232
50	60	3183	99,049	363,242	1.1328	1.7833
100	59	3712	114,884	379,024	2.3354	1.9462
200	64	1982	63,184	369,952	4.5568	1.9072
300	60	3415	106,015	359,896	6.9417	1.3855
400	65	1838	58,910	360,459	9.1786	1.9367
500	65	1838	58,910	331,257	11.5073	1.9367
700	65	1838	58,910	308,258	16.0990	1.9367
1000	65	1838	58,910	259,487	23.1979	1.9367

Table 5
Results of optimal configuration variations of off-grid clean microgrid system under different number of run scenarios.

Number of run	N_{PV}	N_{BESS}	Min.TLCC ($)	Mean. TLCC ($)	Mean.ST (*sec*)	RI (%)
1	52	17,236	520,621	520,621	2.3281	1.5584
20	57	7215	219,969	399,202	2.2625	1.8069
30	59	3712	114,884	379,024	2.3354	1.9462
50	65	1838	58,910	392,069	2.2863	1.9367
75	65	1838	58,910	381,478	2.2831	1.9367
100	65	1838	58,910	401,334	2.3634	1.9367
150	65	1838	58,910	412,716	2.3011	1.9367
200	65	1838	58,910	399,022	2.3261	1.9367

optimization model were applied show that the optimal number of PV and BESS are 65 and 1838 units and the optimal TLCC and RI are $58,910and 1.9367 %. So the mean TLCC is $ 97,277 and mean simulation time is 29.4022 *sec*.

Compared to the base case (when trial solutions is equal to 30, neighbourhood factors is equal to 10, number of iterations is equal to 100, number of runs is equal to 30), it is observed that the optimal number of PV increases by 6 units, the optimal number of BESS decreases by 1874 units, the Min. TLCC value decreases by $55,974, the mean of TLCC value decreases by $281,747, and the mean of ST value increases by 27.0668 *sec*.

Conclusion

In this study, an optimal sizing and evaluation framework are presented for an off-grid clean microgrid system solar/battery energy storage, to generate low-cost green electricity of rural building in China. The optimal sizing of the structure is based on the actual data during a year; with the lowest life cycle cost as the objective function and the maximum reliability. A novel *meta*-heuristic tabu search algorithm is proposed in the solution process to obtain the optimal sizing of the structure in terms of economics and reliability. Additionally, the variations of the optimal sizing of the structure on the basis of different types of reliability index (from 0 to 7 %) and tabu search parameters, such as initial solutions (from 10 to 100), neighborhood structure (from 1 to 50), number of run (from 1 to 200), and number of iteration (from 20 to 1000), is further comprehensively evaluated and investigated. The results of the simulation experiments under the baseline scenario show that the total cost of the clean microgrid structure is decreasing while the RI is increasing and the number of BESS and PV is decreasing as the RI_{max} rate continues to increase. As a result, the reliability of the power supply is reducing. Also, show that when trial solutions is equal to 100, neighbourhood factors is equal to 40, number of iterations is equal to 400, number of runs is equal to 50, the best results will be obtained. Compared to the base case, it is readily apparent that the optimal number of PV increases by 10 %, the optimal number of BESS decreases by 51 %, the Min. TLCC value decreases by 49 %, the mean of TLCC value decreases by 74 %, and the mean of ST value increases by 27.0668 *sec*. Finally, further attempts will be made to construct off-grid clean microgrid system with novel *meta*-heuristic algorithm to provide more secure and reliable energy in the future.

CRediT authorship contribution statement

Yuelin Xu: Writing – original draft, Supervision, Project administration, Conceptualization. **Sihao Huang:** Writing – original draft, Supervision, Project administration, Conceptualization. **Ziwei Wang:** Methodology, Writing – review & editing. **Yiming Ren:** Methodology, Software, Writing – review & editing. **Zikang Xie:** Formal analysis, Investigation, Writing – review & editing. **Jialin Guo:** Resources, Data curation, Writing – review & editing. **Zhilin Zhu:** Resources, Data curation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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