Renewable Energy and Power Quality Journal (RE&PQJ)
ISSN 2172-038 X, Volume No.22, September 2024

Analysis of the Impact of Renewable Energy Application on the Cost of Green Building Projects

Linmei Tang[1]

[1] Sichuan College of Architectural Technology
Deyang, 618000 Sichuan (China)
E-mail: 15181055165@163.com

Abstract. Green building is a sustainable ecological building, and the application of renewable energy to green buildings can protect the ecological environment and reduce energy consumption to a certain extent, so this paper makes an in-depth analysis of the impact of renewable energy application on the cost of green building projects. Firstly, the grey correlation analysis was used to analyze the characteristic indicators of renewable energy applied to the cost of green building projects, and the estimation index system of green building projects was constructed. Then, the improved genetic algorithm was used to construct the explanatory variables and control variables of green building project cost control, the variation factors of green building project cost control were analyzed through principal component analysis, and the elastic modulus and regression discriminant method were combined to complete the impact analysis of renewable energy application to green building project cost. The simulation results show that the algorithm can effectively reduce the economic cost of green buildings, ensure the quality of buildings, and protect the natural ecological environment.

Key words. Renewable Energy, Green Buildings, Project Cost, Improving the Genetic Algorithm.

1. Introduction

At present, the rapid development of science and technology and the continuous acceleration of the world's urbanization process have led to a gradual increase in energy consumption. For the public, energy is an important foundation for promoting the development of civilization, and for a country, energy is an important lifeblood of all development. Accelerate the implementation of sustainable development strategies, improve the coordination mechanism of ecological civilization [1], establish an ecological civilization system, promote the green transformation of the economy and society, and build a modernization of harmonious coexistence between man and nature [2]. Energy can be divided into two types, namely renewable energy and non-renewable energy, of which renewable energy specifically includes solar energy, wind energy and geothermal energy, etc., belongs to a wide range of energy in nature, renewable energy is characterized by a wide distribution and pollution, etc., belongs to an inexhaustible source of energy. Green buildings mainly refer to buildings that provide a healthy, safe and comfortable living and workplace for the public [3], while also using resources efficiently and minimizing the impact on the natural environment. The application of renewable energy to green buildings can effectively reduce the carbon emissions of buildings. It can also alleviate the gradual shortage of energy resources, and has gradually become the main choice of green buildings. Therefore, this paper analyzes the impact of renewable applications on the cost of green building projects [4].

2. Related Work

At present, many experts have studied and analyzed the impact of renewable energy applications on the cost of green building projects, and put forward some analysis results. The impact analysis of renewable energy on the cost of green building projects based on Bayesian network is proposed. First of all, the factors that have an impact on the cost of construction projects are analyzed, the indicators that have an impact on the cost of green building projects are selected, and the indicators are standardized and quantified. It can be seen from the calculation that the accuracy of the impact analysis of renewable energy on the cost of green building projects based on Bayesian network is relatively high [5], so this method can be promoted, but the method still has the problem of a complex process. In order to apply renewable energy to the management of green building projects and improve the accuracy of green building project cost estimation, a convolutional neural network-based renewable energy cost estimation model for green building projects was proposed. Firstly, the influencing factors of green building project cost are analyzed, and combined with the estimation index system of real construction project cost [6]. The estimation model of green building project cost is established by convolutional neural network, and the wolf pack algorithm is used to optimize the weights and biases, so as to improve the optimization efficiency of algorithm parameters. A number of green building projects were used to carry out experimental verification and analysis. The analysis results show that, compared with other neural network models, the convolutional neural network of the wolf pack algorithm can obtain higher accuracy in estimating the cost of green building projects, but the overall estimation efficiency of the algorithm is poor. With the gradual expansion of the

scale of green buildings and the changes in the cost of building materials [7], the overall prediction performance of green building project cost is poor. In order to realize the economic cost control of green building projects, an analysis algorithm of the impact of renewable energy on the cost of green building projects based on game control was proposed. The material structure model of the green building is analyzed, the numerical simulation of the flexible cost and thermal stress gradient boundary of the concrete wall of the green building is carried out, and the constraint relationship function of the economic cost and the production efficiency of the green building is obtained. The prediction and evaluation of the cost of green building projects by the application of renewable energy is realized through the game control algorithm. The simulation results show that the model can realize the prediction and control of the cost of green building projects, and the overall performance is good, but there is a problem of low control accuracy [8].

3. The Estimation Index System of Renewable Energy Application for Green Building Projects Based on Gray Correlation Analysis

The gray correlation analysis is used in the green building project cost estimation index system, specifically according to the curve shape trend of the characteristic index series of green building projects, the closeness between the characteristic index series and the green building project cost series curve, the closer the two curves, the closer the correlation between the series.

Clarify the reference series and comparison matrix of green building project cost. Among them, the comparison matrix specifically refers to the characteristic indicators that the application of renewable energy to green buildings has an impact on the project cost. Suppose that there is m a data sample of green building projects and a characteristic index of green building projects, then the comparison matrix is expressed as:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

In equation (1), the comparison matrix of green building projects X is described, renewable energy is applied to green buildings, and when estimating the cost of green building projects, the cost of green building projects is selected as the reference series value, and the correlation between each building characteristic index and the cost is compared. The value of the reference series is expressed as:

$$X_{i0} = \left[x_{10}, x_{20}, \cdots, x_{m0} \right] \tag{2}$$

In equation (2), $x_{i0}\left(i = 1,2,\cdots,m\right)$ Represents the value of the construction cost of the green building project.

In order to improve the results of green building project cost estimation and ensure the equivalence of green building indicators, the normalized processing of different index values is carried out in a linearized way, which is expressed as:

$$x_{ij} = \frac{x_{ij}}{\max x_{ij}} \tag{3}$$

In equation (3), it represents an index in a green building project x_{ij} , and represents the maximum value of an index in a green building project $\max x_{ij}$.

The correlation coefficient can reflect the degree of correlation between each index and the reference series in the comparison matrix of the green building sample project. Combined with equation (2) and equation (3), the correlation coefficient between any index and the construction cost in the green building project is expressed as follows:

$$\xi_{ij} = \frac{\left| X_{i0} - X_{ij} \right| + \rho \max\limits_{j} \max\limits_{i}}{\left| X_{i0} - X_{ij} \right|} \tag{4}$$

In equation (4), the ρ coefficient of resolution is represented, and the value of the coefficient depends mainly on the difference between the correlation coefficients.

Therefore, this paper collects multiple building data samples, and uses the mean method to clarify that the correlation degree of any index is expressed as:

$$\gamma_j = \frac{1}{m \sum\limits_{i=1}^{m} \xi_{ij}} \tag{5}$$

In equation (5), the degree of association γ_j of any index is expressed, and the correlation degree of the index is sorted, and the greater the degree of association, the greater the index and the overall cost change trend of the construction project, which means that the greater the influence of the index on the reference series.

4. Analysis of the Impact of Renewable Energy Application on the Cost of Green Building Projects Based on Improved Genetic Algorithm

Combined with the above-mentioned construction of renewable energy application of green building project cost estimation index system. The principal component method was used to construct the genetic control variation factor of green building project cost analysis, the vector regression model was established [9], the order characteristics and stationary status of renewable energy application on green building project cost control were comprehensively analyzed, and the genetic adaptive learning method was used to carry out regression analysis on the lag value of green building project cost variables, and the genetic evolution function of green building project cost was

expressed as follows:

$$G_i = \sum\nolimits_i \alpha_j K\left(x_i, x_j\right) - 1 \tag{6}$$

In equation (6), on behalf of the relevant influencing factors such as prices and markets, the structural parameters of the risk factors of green building project $\alpha_j K$ cost control are expressed, and the economic benefit discriminant expression of green building project cost is obtained through the analysis of related factors according to the investment rate of green building project.

$$G_i = \begin{cases} \geq 0, \alpha_i = 0 & S_R \\ \geq 0, 0 \prec \alpha_i & S_S \\ \leq 0, \alpha_i = C & S_E \end{cases} \tag{7}$$

Equation (7) represents the production capacity of green building assets, the evaluation function of the production capacity of green buildings and the $\sum_{i=1}^{t} y_i \alpha_i = 0 S_R$ replacement cost of green buildings, the total amount of production capacity and financial assets, and the subset of production capacity and grade gradient values. Based on the analysis of steady-state parameters, the genetic variation factor of renewable energy application on the cost control of green building projects is constructed, and the capital pricing model is established through genetic adaptive learning, and the genetic learning model of green building project cost is established $S_S S_E$.

Through the results of green building project cost control and prediction, elastic modulus analysis and regression discriminant analysis, the improved genetic algorithm is used to realize the prediction and control of green building project cost, and the characteristic distribution of the principal components of green building project cost is expressed as follows:

$$F_U = \sum_{j=1}^{M} \min_{j \in N_j} \left(F_{jk}\right) \tag{8}$$

$$F_v = \sum_{j=1}^{M} \max_{j \in N_j} \left(F_{jk}\right) \tag{9}$$

In the above formula, the fuzzy dynamic parameters representing the principal components of the cost of green building projects, the characteristic parameters representing the constraint dynamics, according to the degree of cumulative variance contribution, combined with the evaluation factor assessment, can obtain the evaluation model function of green building project cost control as follows:

$$F_i = \sum_{k=1}^{M} \sum_{j \in N_j} x_{jk} F_{jk} \tag{10}$$

In equation (10), the quantitative characteristic parameters of the cost of green building projects are analyzed, the distribution feature set of genetic parameters of green building project cost is obtained, and the global optimization control is carried out through equation (10), and the estimated value of the parameters of green building project cost control is expressed as:

$$p_k^w = \frac{f_k^w}{q^w} = \frac{\exp\left(-\theta c_k^w\right)}{\sum_{k=1} \exp\left(-\theta c_k^w\right)} \tag{11}$$

In equation (11), the replacement cost of the reference asset, the index representing the economies of scale, and the parameters representing the excess operating $f_k^w \theta c_k^w$ cost of the green building, combined with the above analysis of equations (10) and equations (11), using the dynamic model parameter analysis, the improved genetic algorithm is completed by equations (11) and equations (12) to realize the prediction and control of green building project cost, and the optimized green building engineering control parameter solution is expressed as:

$$q^w \left\{ \left[\lambda_w \eta^w + \mu_w + \hat{f}_k^w \right] - q^w \right\} \geq 0 \tag{12}$$

$$C = \left(1 - \lambda + \lambda t\right) t^3 \tag{13}$$

The above formula, represents the distribution of the economic benefit index, the dynamic adjustment parameters in the process of construction project cost, the number of training samples for the impact analysis of renewable energy application on the cost of green building projects $\lambda_w \mu_w \hat{f}_k^w w\lambda$, the optimal solution obtained, and t the response time of construction project cost control. The elastic modulus analysis and regression discriminant analysis method are combined to analyze the impact of renewable energy application on the cost of green building projects by the improved genetic algorithm, and the specific implementation process is shown in Figure 1.

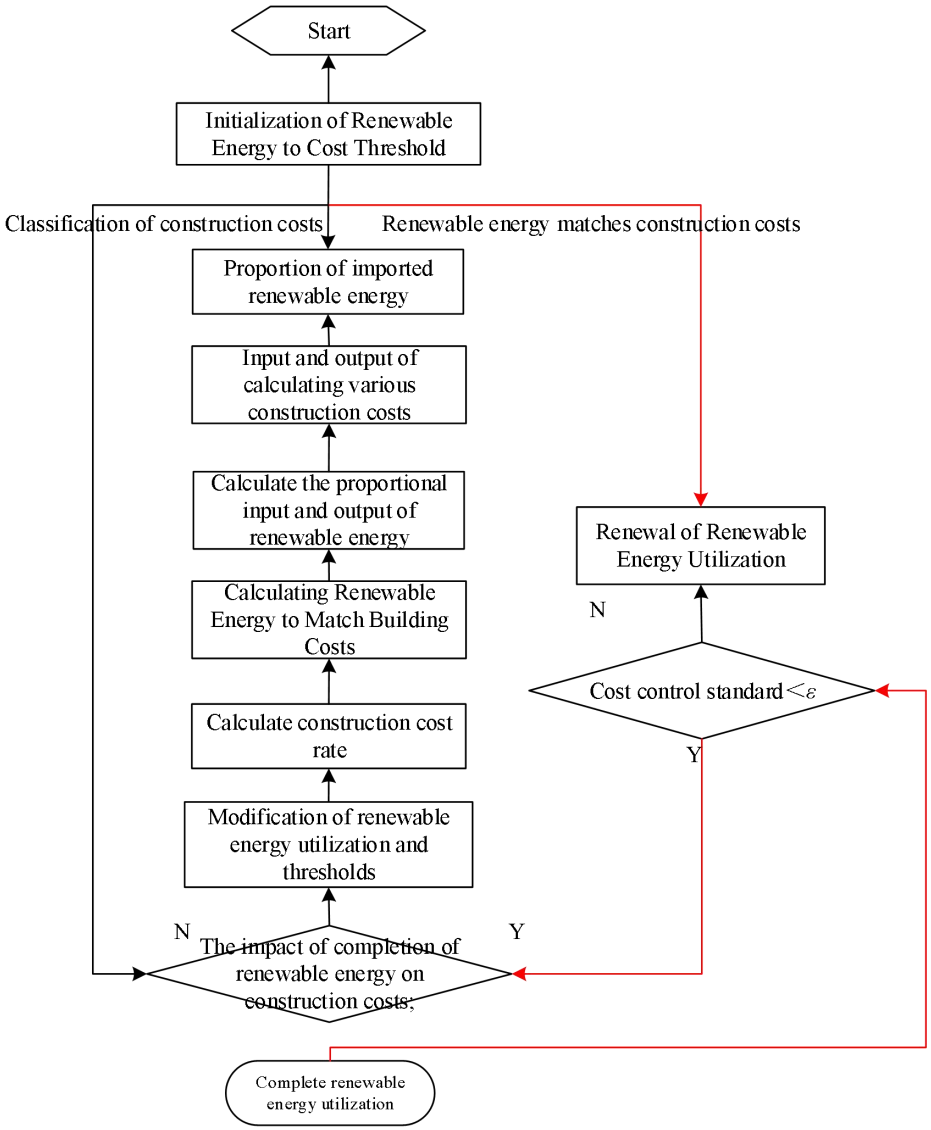

Figure 1. The Detailed Process of Improving the Genetic Algorithm

5. Experimental Results

A. Introduction to the Experiment of Green Building Project Cost

In order to test the comprehensive performance of the impact analysis of the application of renewable energy with improved genetic algorithm on the cost of green building projects proposed in this paper, a building in a city was taken as the research object to carry out a simulation experiment, and the operating environment of the simulation experiment was represented by Table 1.

Table 1. Experimental Operating Environment

OPERATING ENVIRONMENT	DATA
Operating system	Windows Server
Program development platform	MYeclipse10i
Application server	IBM Server X3650M5 8871I
Processor	Dual-socket CPUi7-260V4

B. The Cost Impact of Renewable Energy on the Cost of Green Projects

Through the systematic analysis of the project cost, the results of the factory cost can be preliminarily obtained, and the summary of various costs of green buildings is shown in Table 2.

Table 2. Summary of Green Building Costs

PROJECT	AMOUNT/10,000 YUAN	PERCENTAGE/%
Cost	4308	100
Labor costs	464	10.9
Material costs	2365	62.4
Machinery costs	1504	3.27
Profits & Taxes	270	9.33

The hysteresis curve of construction cost control for the impact analysis of renewable energy application to green building project cost is shown in Figure 2.

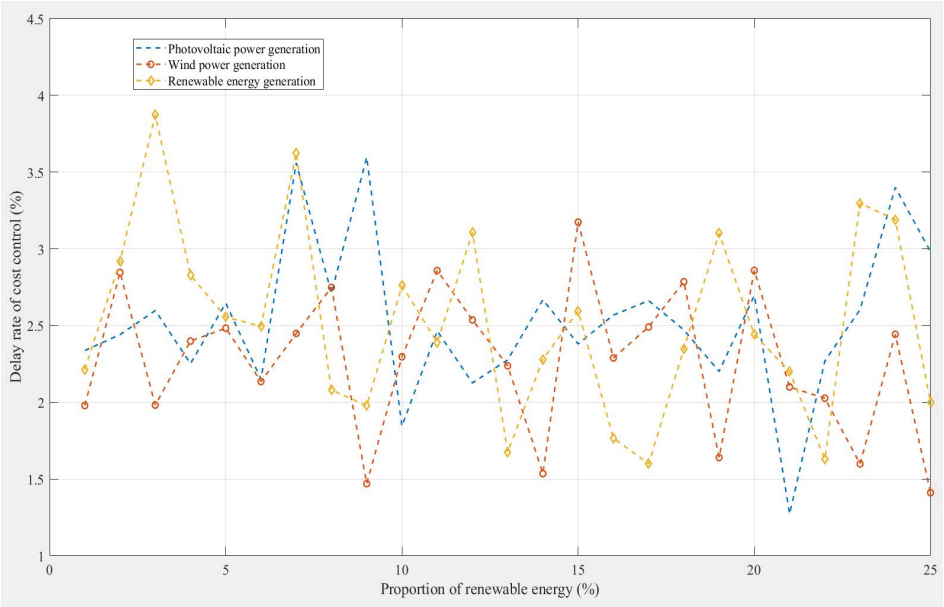

Figure 2. Hysteretic Curve of Cost Control of Green Building Project

It can be seen from Figure 2 that the improved genetic algorithm proposed in this paper can realize the control of the cost of green building projects, thereby improving the level of building stress, reducing the cost of green building projects, and further verifying the impact analysis of renewable energy applications on the cost of green building projects. The actual project cost of the green building studied in this paper is 1,562,596.32 yuan.

C. Forecast of Renewable Energy on the Cost of Green Building Projects

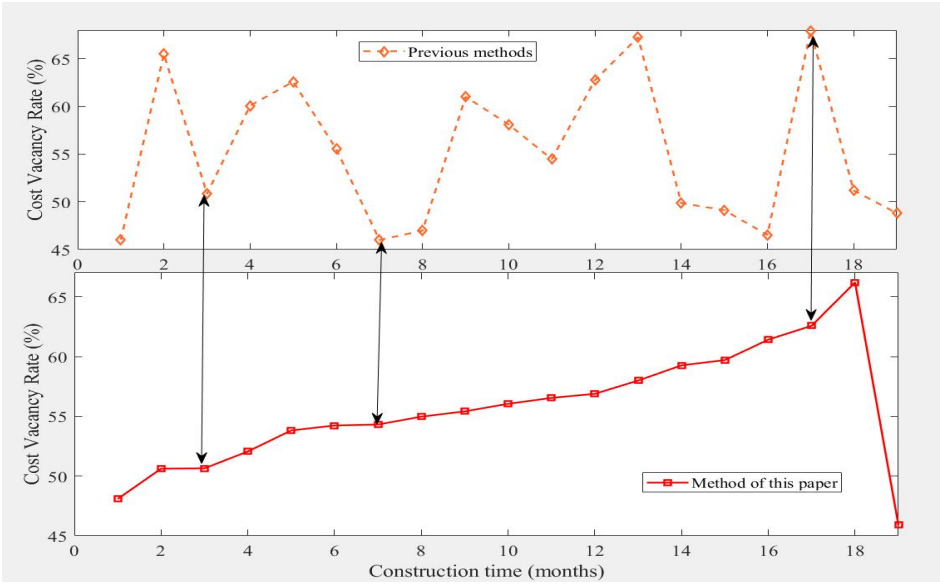

Figure 3. Comparison of Green Building Project Cost Budgets with Different Algorithms

The analysis of Figure 3 can be seen that the estimated budget of green building projects using particle swarm algorithm changes relatively largely, and the lowest estimated budget of green building projects is 15.435 million yuan, which is different from the actual cost of green building projects, indicating that the estimated budget error of particle swarm algorithm is relatively large, and the estimated budget of green building projects using ant colony algorithm is 15.694 million yuan, which is relatively higher than the actual cost of green building projects, indicating that there are problems such as misleading project information in the process of green building project cost, and the estimated cost of green building projects using the improved genetic algorithm proposed in this paper is 15.621 million yuan. The difference between the cost of green building and the actual green building project is small, and the data calculation is more accurate, which shows that the application of renewable energy to the cost of green building can reduce the economic construction cost of green building [9].

D. The Control Rate of Renewable Energy on the Cost of Green Building Projects

Renewable energy is applied to green buildings, and three algorithms are used to calculate the building management and maintenance fees and maintenance service fees incurred in the operation of green building projects, and the year is set to 5 years, and the operating costs of green buildings with different algorithms are shown in Figure 4.

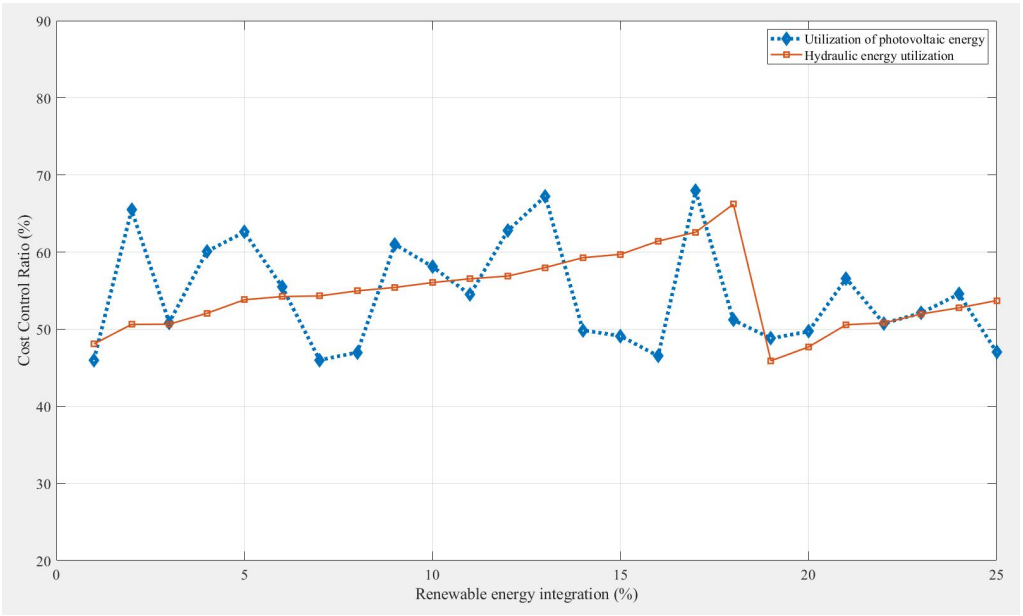

Figure 4. Comparison of Green Building Operating Costs with Different Algorithms

The analysis of Figure 4 shows that the operating cost of green buildings with improved genetic algorithm proposed in this paper is relatively low, while the operating cost of green buildings using particle swarm algorithm can reach up to 230,000 yuan, and the operating cost of green buildings using ant colony algorithm can reach up to 210,000 yuan. This shows that the other two algorithms have a poor effect on green building project cost control, while the algorithm proposed in this paper has a better effect on green building project cost control and has certain practicability. Table 3 shows the comparison of the cost estimation error of green building projects using the improved genetic algorithm, particle swarm algorithm and ant colony algorithm proposed in this paper [10].

Table 3. Comparison of Cost Estimation Errors of Green Building Projects with Different Algorithms

DIFFERENT ALGORITHMS	ERROR/%
Improving the genetic algorithm	1.2
Particle swarm algorithm	8.9
Ant colony algorithm	12.3

It can be seen from Table 3 that the error of the three different algorithms for the cost estimation of green building projects is not the same, and the error of the cost estimation of green building projects using the improved genetic algorithm proposed in this paper is lower [11], while the errors of the cost estimation of green building projects of the other two algorithms are higher than those proposed in this paper, which reduces the effectiveness of the algorithm, which shows that the algorithm proposed in this paper is very suitable for application to the analysis of the impact of renewable energy on the cost of green building projects, and has certain application value [12].

6. Conclusion

Under the premise of the gradual scarcity of natural resources and the acceleration of urbanization in China, it is very important to study the application of renewable energy in the cost of green building projects. Based on the theories related to green building cost and renewable energy, this paper discusses the impact of renewable energy application on the feasibility of green building projects. Firstly, the grey correlation analysis is used to analyze the engineering characteristics of renewable energy applied to the cost of green building projects, and then the improved genetic algorithm is used to construct the explanatory variables and control variables of the cost control of green building projects, and the effectiveness of the proposed algorithm is verified through simulation experiments, and the verification results show that the application of renewable energy to the cost of green building projects can effectively reduce the economic cost of green buildings and is of great significance to the protection of the ecological environment.

References

[1] A. N. Abdalla *et al*., "Integration of energy storage system and renewable energy sources based on artificial intelligence: An overview," *Journal of Energy Storage*, vol. 40, p. 102811, 2021.

[2] A. Almutairi, K. Sayed, N. Albagami, A. G. Abo-Khalil, and H. Saleeb, "Multi-port PWM dc-dc power converter for renewable energy applications," *Energies*, vol. 14, no. 12, p. 3490, 2021.

[3] A. Karaaslan, T. Adar, and E. K. Delice, "Regional evaluation of renewable energy sources in Turkey by new integrated AHP-MARCOS methodology: A real application," *International Journal of Sustainable Energy*, vol. 41, no. 2, pp. 103-125, 2022.

[4] L. Li and X. Wang, "Design and operation of hybrid renewable energy systems: Current status and future perspectives," *Current Opinion in Chemical Engineering*, vol. 31, p. 100669, 2021.

[5] N. T. Mbungu, R. M. Naidoo, R. C. Bansal, M. W. Siti, and D. H. Tungadio, "An overview of renewable energy resources and grid integration for commercial building applications," *Journal of Energy Storage*, vol. 29, p. 101385, 2020.

[6] A. G. Olabi, M. A. Abdelkareem, and H. Jouhara, "Energy digitalization: Main categories, applications, merits, and barriers," *Energy*, vol. 271, p. 126899, 2023.

[7] Olusola, Joshua, and Olujobi, "The legal sustainability of energy substitution in Nigeria's electric power sector: Renewable energy as alternative," *Protection and Control of Modern Power Systems*, vol. 5, no. 4, pp. 1-12, 2020.

[8] M. M. Rahman, I. Khan, D. L. Field, K. Techato, and K. Alameh, "Powering agriculture: Present status, future potential, and challenges of renewable energy applications," *Renewable Energy*, vol. 188, pp. 731-749, 2022.

[9] Y. Sun, Z. Zhao, M. Yang, D. Jia, W. Pei, and B. Xu, "Overview of energy storage in renewable energy power fluctuation mitigation," *CSEE Journal of Power and Energy Systems*, vol. 6, no. 1, pp. 160-173, 2019.

[10] Y. Wu, T. Zhang, R. Gao, and C. Wu, "Portfolio planning of renewable energy with energy storage technologies for different applications from electricity grid," *Applied Energy*, vol. 287, p. 116562, 2021.

[11] Zhao, Y., S. Xia, J. Zhang, Y. Hu, and M. Wu, "Effect of the digital transformation of power system on renewable energy utilization in China," *IEEE Access*, vol. 9, pp. 96201-96209, 2021.

[12] G. Zhou, Q. Tian, and L. Wang, "Soft-switching high gain three-port converter based on coupled inductor for renewable energy system applications," *IEEE Transactions on Industrial Electronics*, vol. 69, no. 2, pp. 1521-1536, 2021.