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The Impact of Renewable Energy on Low Energy Consumption in Civil Engineering Construction

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Abstract. As the main representative of new energy, photovoltaic energy is widely used in civil engineering construction, its purpose is to reduce the energy consumption in the project, there is a deviation in the integration of new energy and civil engineering, and it cannot effectively play its own advantages. Continuously analyze the changes in the energy consumption values of civil engineering. Then, the influencing factors of building energy consumption were introduced, and the covariance matrix was constructed, and the engineering construction benefit was taken as the ultimate goal. When calculating energy consumption, the dual benefits of building benefits are fully considered, and environmental protection and engineering energy consumption are estimated to reduce the error of energy consumption calculation. The results show that new energy can reduce the high energy consumption value in the project, improve the light transmittance, enhance the conversion rate of sunlight, and provide support for the transportation, lighting and thermal insulation of the building, with an increase rate of 10~25%, and the new energy can reduce the cost of civil engineering, with a reduction rate of 19~26%, and improve the economic and social benefits, with an increase of more than 10%. Therefore, new energy can reduce the energy and energy consumption of civil engineering, and expand the scope and application depth of new energy development.

Key words. Renewable Energy, Civil Engineering, Construction, Low Energy Consumption.

1. Introduction

With the rapid progress of modern society and the gradual expansion of urban scale, the energy consumption of the project has soared, and the budget investment and management of the project are facing severe challenges. In this case, the construction unit must take the energy consumption of the project as a key link in project management, increase the green and low-energy construction projects, save the cost budget, and carry out all-round management control. Previous studies have shown that for green and ecological low-energy building projects, the site should be located in an area with sufficient sunlight [1], [2], good ventilation and superior terrain, but the energy consumption of transportation and materials in the construction of pre-engineering projects is increasing day by day. In particular, some of the buildings have peculiar shapes and designs, with extra-high floors. Although some projects are integrated with the natural ecology to achieve a sustainable and nature-friendly green space distribution of the environment and buildings, the overall energy consumption has not decreased [3], [4]. In 2021, the total energy consumption of civil engineering projects in the country was 12.423 billion KJ, which will rise to 25.432 billion KJ in 2023. Among them, the energy consumption of insulation, lighting and transportation accounts for the highest proportion, so some scholars believe that the application of photovoltaic energy to buildings to reduce the energy consumption of the entire building is lacking effective verification cases. Some scholars believe that the application of new energy sources such as wind power and photovoltaic power to buildings can enhance the overall structure of the building, reduce the later maintenance cost of the building, and realize the sustainable reduction of energy consumption of the building as a whole. Some scholars question the application effect and degree of application of new energy, believing that new energy cannot replace the traditional energy structure, and will increase the instability of buildings [5], [6], and some scholars believe that new energy as a new type of energy and its use time and cycle are relatively short, and the maintenance cost and failure rate in the later stage after the integration of the building are high, and it is difficult to achieve sustainable construction, so there is a great controversy about the integration of new energy and civil engineering construction [7],[8]. There are many uncertainties encountered in the construction of green buildings, which makes it too complicated to predict the energy consumption values of green and ecological low-energy building projects. Therefore, the construction unit must carry out cost planning for green and energy-saving construction projects. In the past, the energy consumption of construction projects in China was relatively old-fashioned, mainly relying on manual recording and estimation, and collecting the actual cost for calculation. By comparing the contract unit price, the actual cost and the tax revenue, the numerical benefit of energy consumption can be obtained. However, the results of this budgeting approach are often biased. Based on the new energy, this paper analyzes the data, uses mathematical algorithms to evaluate its energy consumption, including

transportation, construction and curing, and lighting, etc., and realizes the overall structure optimization of new energy, verifies the effectiveness of new energy through actual cases, so as to enhance and promote the application of new energy, firstly, this paper uses dynamic regression analysis method to collect new energy data, and removes and identifies the abnormal data and key data to reduce the amount of data, and then analyzes the application of new energy station temperature, solidification, lighting, transportation, etc., and calculates its failure rate and cost sum, so as to verify the application effect of new energy in civil engineering, and finally according to the implementation technology of new energytechnology and implementation methods, theoretical and strategic analysis to support the construction of related civil engineering[9], [10].

2. Analysis of the Role of New Energy in Civil Engineering

A. *Energy Consumption of Civil Engineering Buildings*

Civil engineering construction provides a basis for the subsequent application of new energy. Through the analysis of inverse science and new energy theory, the energy consumption and cost are obtained by solving the construction state at each moment of the known project. Using the regression analysis method, the energy consumption and cost of key construction projects can be calculated by the following formula:

$$F_i = m\dot{v}_{c_i} \tag{1}$$

Among them, the m scale of construction is described; v_{ci} Indicates the progress of construction; ${}^{i\in[0,100]}$; ${}^{i+1}F_{i+1}$ and ${}^{i+1}N_{i+1}$ the energy consumption of photovoltaic and wind power generation technologies in cement pouring and transportation; ${}^{m_{i+1}}$ For the stability of photovoltaic and wind power generation. At the same time, there should be integration between different links, $N_I$which is calculated as shown in equation (2).

$$N_i = {}^{c_i}I\dot{\boldsymbol{\omega}}_i + \boldsymbol{\omega}\cdot{}^{c_i}I\boldsymbol{\omega}_i \tag{2}$$

where: ^{C_i} represents the proportion of new energy applications; ${}^{c_i}I$ indicates the development potential of new energy; $\boldsymbol{\omega}_i$ and $\dot{\boldsymbol{\omega}}_i$ indicates the degree of energy savings and savings; ${}^{c_{i+1}}I_{i+1}$ It is the $i{+}1$ utilization rate of new energy during the construction period.

The civil engineering building consists of two parts, the first part is the recursive calculation from the initial duration 1 to the duration n and the second part n is the depth calculation from the duration to the duration 1, and the two interact and drive. For the calculation of civil engineering, the algorithm is summarized as follows.
The energy consumption optimization process of project n is calculated as follows:

$${}^{i+1}\boldsymbol{\omega}_{i+1} = {}^{i+1}\boldsymbol{R}^i\boldsymbol{\omega}_i \rightarrow \dot{\theta}_{i+1}{}^{i+1}\hat{\boldsymbol{Z}}_{i+1} \tag{3}$$

The reduction in energy consumption is ${}^{i+1}\dot{\boldsymbol{\omega}}_{i+1}$ calculated as follows:

$${}^{i+1}\dot{\boldsymbol{\omega}}_{i+1} = {}^{i+1}\boldsymbol{R}^i\dot{\boldsymbol{\omega}}_i \rightarrow {}^{i+1}\boldsymbol{R}^i\boldsymbol{\omega}_i\cdot\dot{\boldsymbol{\theta}}_{i+1}{}^{i+1}\hat{\boldsymbol{Z}}_{i+1} \leftarrow \ddot{\boldsymbol{\theta}}_{i+1}{}^{i+1}\hat{\boldsymbol{Z}}_{i+1} \tag{4}$$

Among them, ${}^{i+1}\boldsymbol{\omega}_{i+1}$ and ${}^{i+1}\dot{\boldsymbol{\omega}}_{i+1}$ represents $i+1$ the vector between the new energy electricity consumption and the proportion of new energy of the project, realizes the standardization of data, reduces the cost caused by energy consumption ${}^{i+1}\dot{v}_{i+1}$, $\ddot{\theta}_{i+1}$ represents $i+1$ the proportion of new energy of the project, and $\dot{\theta}_{i+1}$ represents $i+1$ the new energy consumption of the project, which is calculated as

$${}^{i+1}\dot{v}_{i+1} = {}^{i+1}R\cdot\left({}^{i}\dot{\boldsymbol{\omega}}_i\cdot{}^{i}\boldsymbol{P}_{i+1} + \Delta{}^{i}\boldsymbol{\omega}_i\cdot\left({}^{i}\boldsymbol{\omega}_i\cdot{}^{i}\boldsymbol{P}_{i+1}\right)\Big/{}^{i}\dot{v}_i\right) \tag{5}$$

The ${}^{i+1}\dot{v}_{i+1}$ sum represents the reduction of energy consumption of ${}^{i+1}\dot{v}_{C_{i+1}}$ photovoltaic and wind power generation $i+1$; The amount of continuous development of energy consumption is ${}^{i+1}\dot{v}_{C_{i+1}}$ calculated as follows:

$${}^{i+1}\dot{v}_{C_{i+1}} = {}^{i+1}\dot{\boldsymbol{\omega}}_{i+1}\cdot{}^{i+1}\boldsymbol{P}_{C_{i+1}} \rightarrow \Delta{}^{i+1}\boldsymbol{\omega}_{i+1}\cdot\left({}^{i+1}\boldsymbol{\omega}_{i+1}\cdot{}^{i+1}\boldsymbol{P}_{C_{i+1}}\right) \rightarrow \Delta{}^{i+1}\dot{v}_{i+1} \tag{6}$$

Finally, the reaction of energy consumption to the development of new energy is as follows

$${}^{i}f_i = {}_{i+1}{}^{i}\boldsymbol{R}^{i+1}f_{i+1} \leftrightarrow {}^{i}F_i \tag{7}$$

Among them, it represents the ${}^{i+1}\boldsymbol{R}$ energy consumption transformation matrix between adjacent projects of the building; The optimization of the new energy structure is as follows

$${}^{i}\boldsymbol{n}_i = \sqrt{{}^{i}N_i\cdot{}_{i+1}{}^{i}\boldsymbol{R}^{i+1}\boldsymbol{n}_{i+1} + \sum{}^{i}\boldsymbol{P}_{c_i}\cdot{}^{i}F_i}\,/\,{}^{i}\boldsymbol{P}_{i+1} + \Delta\boldsymbol{R}^{i+1}f_{i+1} \tag{8}$$

Among them, ${}^{i}f_i$ and ${}^{i}\boldsymbol{n}_i$ represents i the energy consumption and cost on the construction period; ${}^{i}\boldsymbol{P}_{i+1}$ represents the energy consumption vector of $i+1$ the previous civil engineering project during the construction period i; ${}^{i+1}\boldsymbol{P}_{C_{i+1}}$ It represents the energy consumption $i+1$ of cement pouring and transportation during the construction period i.

The overall impact of new energy on civil engineering is as follows:

$$\sum\tau_i = \frac{{}^{i}\boldsymbol{n}_i^{\mathrm{T}i}\cdot\hat{\boldsymbol{Z}}_i}{2} \tag{9}$$

Among them, the unit vector representing ${}^{i}\hat{\boldsymbol{Z}}_i$ the degree of optimization along the energy consumption structure in i the construction period z ; τ_i for the overall impact of new energy on civil engineering.

B. The Impact of New Energy on Civil Engineering Construction

For the energy consumption of civil engineering in various forms of new energy, the Euler equation can be constructed to consider the interaction within civil engineering, and the calculation process is more complicated. However, the fusion regression analysis method only needs to consider the energy term of civil engineering, which can simplify the expression of the formula and realize the comprehensive analysis of multiple forms of new energy, and the specific calculations are expressed as follows:

$$\sum \tau_i = \frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{\theta}_i}\right) - \frac{\partial L}{\partial \theta_i} + \alpha \tag{10}$$

where: τ_i the i amount of energy consumption reduction for the project; θ_i and $\dot{\theta}_i$ the adjustment coefficient of the relationship between energy consumption and renewable energy electricity consumption; L is a moderation function, whose value is equal to the difference between the total and actual energy consumption of the civil engineering, i.e L=K－P.

For a civil engineering project with a construction period, new energy technology and new energy structure, its energy consumption assessment can be expressed as:

$$K = \frac{1}{n}\sum_{i=1}^{n}\sum_{p=1}^{n}\sum_{r=1}^{i}\text{power}\left(\boldsymbol{U}_{ip} \cup \boldsymbol{J}_i \cup \boldsymbol{U}_{ir}^{\mathrm{T}}\right)\dot{q}_p \to \dot{q}_r + \frac{1}{n}\sum_{i=1}^{n}\boldsymbol{I}_{i(\text{act})} \cdot \dot{q}_i \cdot \dot{q}_i \tag{11}$$

where: $\boldsymbol{U}_{ip}$ sum $\boldsymbol{U}_{ir}$ is the derivative of the energy consumption matrix of different durations; $\boldsymbol{J}_i$ and $\boldsymbol{I}_i$ represent the new energy supply matrix and the application matrix, respectively.

The impact of new energy on civil engineering construction is equal to the sum of energy consumption in each construction period, which can be expressed as:

$$P_{totle} = \frac{\sum_{i=1}^{n}\left[-m_i g \cdot \left({}^{0}T_i \cdot \overline{r_i}\right)\right]}{\max(P_i)} \tag{12}$$

where: g the degree of influence of energy consumption; ${}^{0}T_i$ is the i relative application rate of new energy in the construction period; $\overline{r_i}$ is the energy consumption of cement pouring and transportation in the project. The Lagrangian equation for the civil engineering of the robotic arm is expressed as:

At the same time, the energy consumption of different civil engineering projects is as follows:

$$\tau_i = \sum_{j=1}^{n}\boldsymbol{D}_{ij}\ddot{q}_j + I_i\ddot{q}_i + \sum_{j=1}^{n}\sum_{k=1}^{n}\boldsymbol{D}_{ijk}\dot{q}_j\dot{q}_k + \boldsymbol{D}_i \tag{13}$$

Among them, the impact of new energy on energy consumption in transportation is as follows:

$$\boldsymbol{D}_{ij} = \sum_{p=\max(i,j)}^{n}\text{Trace}\left(\boldsymbol{U}_{pj}\boldsymbol{J}_p\boldsymbol{U}_{pi}^{\mathrm{T}}\right) \tag{14}$$

The impact of new energy on thermal insulation energy consumption is as follows:

$$\boldsymbol{D}_{ijk} = \sum_{p=\max(i,j)}^{n}\text{Trace}\left(\boldsymbol{U}_{pjk}\boldsymbol{J}_p\boldsymbol{U}_{pi}^{\mathrm{T}}\right) \tag{15}$$

The impact of new energy on lighting energy consumption is as follows:

$$\boldsymbol{D}_i = \sum_{p=i}^{n} - m_p g^{\mathrm{T}}\boldsymbol{U}_{pi}\overline{r_p} \tag{16}$$

where: $\boldsymbol{D}_{ij}$ is the energy consumption matrix; I_i is the influence coefficient and degree of new energy; $\boldsymbol{D}_{ijk}$ for the degree of integration of new energy and buildings; $\boldsymbol{D}_i$ is the impact of external interference on the application of new energy.

3. Practical Case Analysis

A. Case introduction and elaboration

In order to verify the feasibility of the model, this paper takes the low-rent housing project as the research object, the civil engineering is a brick-concrete structure and is constructed in the form of cement pouring, in which the foundation is driven into a depth of 25 meters, the concrete is marked C10, and the thermal insulation is carried out in the form of photovoltaic solar panels and electric heating during the construction process, and wind power generation is used for lighting, in which the computer of photovoltaic and wind power generation is stored in a phosphoric acid battery, where the photovoltaic power generation time is from 5 am to 8 pm, and the wind power generation is 24 hours, The project is located between 40~45 degrees north latitude in the northern hemisphere. During the test, the computer used did not have an IBM server, which had 32 GB of RAM and a processing speed of 3.6 Ghz. The civil works will be carried out in three phases and will last for a total of 12 months, with the foundation being poured in the early stage and the photovoltaic equipment being installed in the later stage.

The data collection methods are historical data and real-time test data, and the data analysis methods are subjective analysis and objective analysis, and the complex data is simplified and verified by the classification method, as shown in Figure 1.

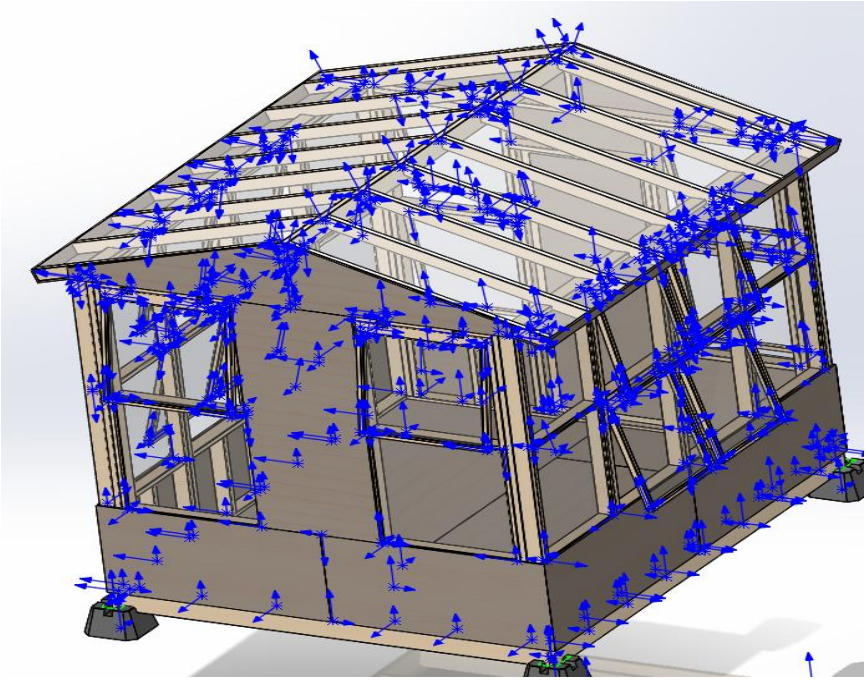

Figure.1 Construction renderings of low-rent housing

As can be seen from Figure 1, the upper and lateral parts of the civil engineering project are photovoltaic solar panels, and the bottom is a phosphoric acid battery, which is mainly used for wind power and photovoltaic power generation storage.

Numerical energy consumption prediction in civil engineering requires the help of historical and actual test data.

Among them, the problem is that the energy consumption numerical data is very different from the predicted data, which makes it difficult to predict the energy consumption value. The actual energy consumption may be higher than the prediction, so the
coefficient should be adjusted.

B. The energy consumption of new energy for civil engineering construction is reduced

By comparing the energy consumption of phase I~III, the impact of new energy on the energy consumption of civil engineering is calculated, and the error responsiveness and mean square deviation have been calculated, and the results are shown in Table 1.

Table 1. Energy Consumption of Civil Engineering [Unit: J mm^3]

Energy Consumption		**Duration**			**Project**		
		I	**II**	**III**	**Heat Preservation**	**Transport**	**Illumination**
Photovoltaic	8:00~12：00 am	631.02	428.57	386.47	16.65	-0.27	
	12:00~16：00 am	203.29	2739.09	1486.06	-11.78	-829.43	21.57
	16:00~20：00 am	38685.45	758.96	3146.75	-4674.62	-47.97	1923.32
	20:00~24：00 am	382.13	2389.74	138.25	-0.74	-339.70	-5.84
Wind Power	8:00~12：00 am	4986.71	5640.66	2346.72	-330.49	-201.12	64.44
	12:00~16：00 am	533.13	684.52	1714.69	-30.42	-88.91	-11.68
	16:00~20：00 am	1866.99	1533.47	475.96	12.65	-87.49	-41.35
	20:00~24：00 am	296.75	359.67	612.26	-23.08	-61.71	20.21

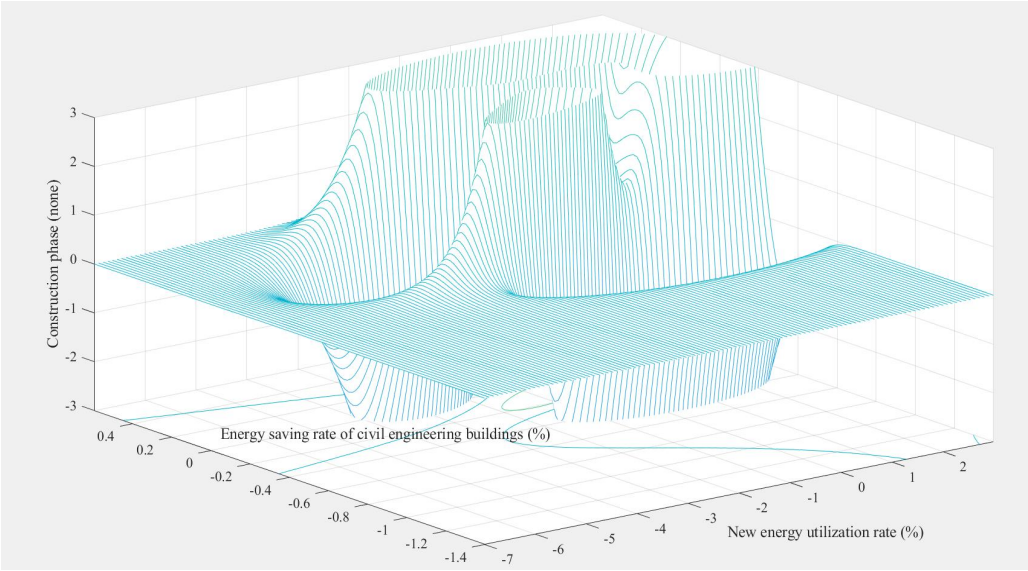

Figure 2. The Impact of Renewable Energy on the Energy Consumption of Civil Engineering

The energy consumption can be calculated, and the energy consumption results can be obtained at different times, asshown in Figure 2.

From the data in Figure 2, when estimating energy consumption for transportation, insulation, and landline lines, the energy consumption will change with the change of the estimated value, and there is a significant difference in the response rate. When the civil engineering project reaches phase III, the energy consumption reduction rate will be greatly improved. The previous energy consumption control method was less than 60%, which did not meet the set energy consumption standards, proving that renewable energy has a strong capacity. The results of the analysis of the square root of the energy consumption prediction at different stages are as follows.

Table 2. Verification of Energy Consumption by New Energy Sources

Project	Theoretical Value/JK	Emulation Value/JK	Error Value/JK	Error Percentage/%
Transport	12.32	85.36	0.06	10.32
Heat Preservation	562.32	45.32	0.02	4.63
Illuminating	56.32	3.42	056	5.96

C. 3.3 Changes in energy consumption in various parts of civil engineering

There are also large differences in the energy consumption of different locations of civil engineering projects, and the average deviation between different locations is 10%, and the average deviation of budget management is always less than the actual deviation, indicating that new energy has a significant impact on the energy consumption saving of civil engineering.

Table 3. Changes in Energy Consumption at Different Locations (Unit: %)

Location	Rate Of Change In Energy Consumption	Energy Savings In Transportation	Thermal Insulation Energy Saving		Illuminating	
			At Night	Daytime	Daytime	At Night
Upper Portion	10.11%	10.01%	9.45%	13.21%	39.02%	43.13%
Lower	10.12%	1.01%	9.65%	13.65%	39.25%	43.98%
Front	10.12%	10.01%	9.87%	13.23%	40.01%	43.98%
Rear	10.13%	10.02%	9.99%	13.34%	41.87%	43.98%
Bottom	10.13%	10.02%	10.23%	14.12%	41.78%	43.98%
Central	10.14%	10.02%	10.34%	14.44%	41.98%	43.98%

It can be seen that the energy consumption changes in different locations are obvious, and the overall energy consumption change rate is stable. Among them, the saving rate of insulation and lighting is higher, mainly because the research on new energy in the above aspects is relatively mature, while the application of transportation is relatively poor. The changes in energy consumption at different locations are obtained through the observation of historical data, as shown in the figure below.

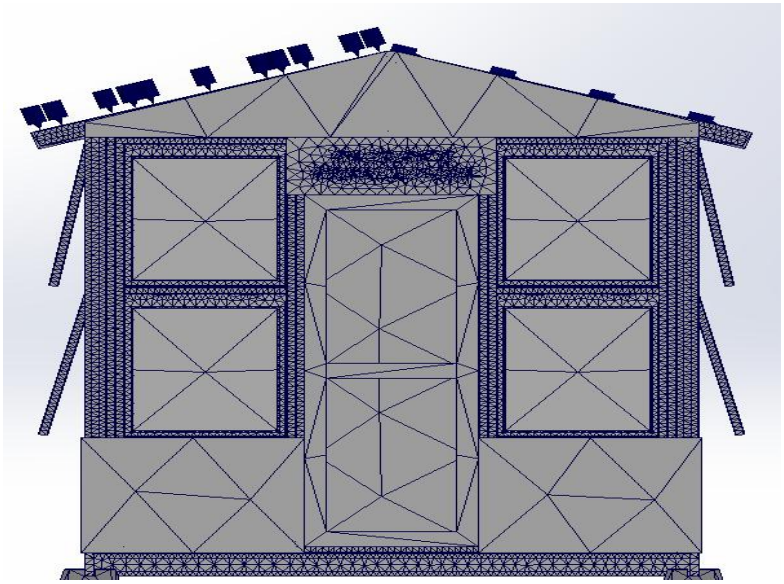

Figure 3. Comparison of Front Energy Consumption with Overall Energy Consumption

As can be seen from Figure 3, there is a difference between the overall energy consumption and the distributed energy consumption of the building, mainly because the photovoltaic power generation effect is significant, and the specific photovoltaic power generation effect is shown in Figure 4.

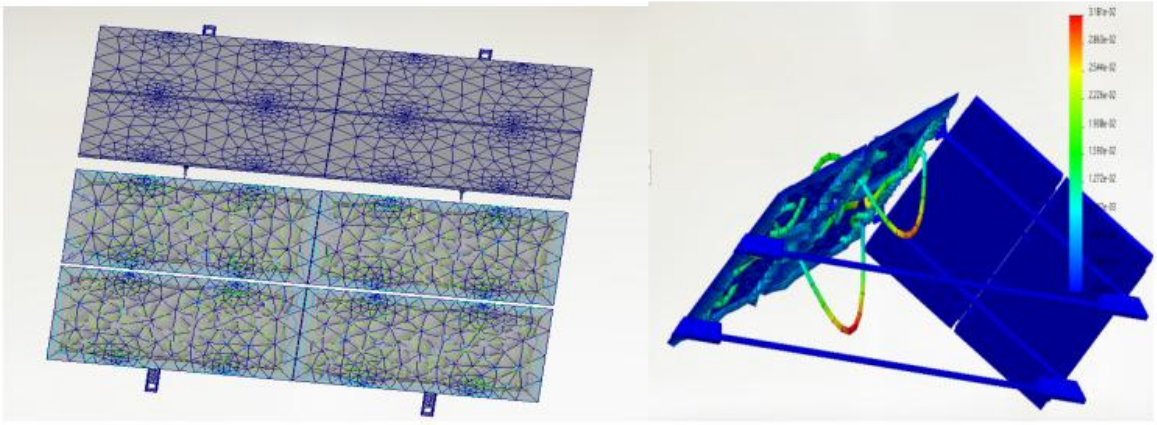

Figure 4. Energy Changes in Photovoltaic Power Generation

According to the data in Figure 4, in the analysis of light, transportation and lighting, it is found that the effect of photovoltaic power generation is better, which can improve the lighting effect at night, and the integrity of the data, at the same time, photovoltaic as the main content of new energy, can greatly save energy consumption, and then reduce transportation costs. During the test, the relationship between cost and energy consumption was shown to be 1:5.2, so there was a positive correlation between the two. Through comparative research, it is found that photovoltaic power generation has a relatively simple process and a wide range of applications, whether it is for residential or public building projects, the construction process is relatively stable, and it can be quickly installed, which is a combination of new energy and civil engineering. Therefore, the local government should adjust the proportion between wind power generation and photovoltaic power generation according to the application of photovoltaic energy, and introduce the actual application plan and skills of new energy, such as the suspension method of new energy in engineering construction and the implementation ratio of new energy and engineering proposal system, which is equal to ensure the engineering and quality of new energy and civil engineering construction.For example, "Local New Energy Application Measures", "ISO900 Certification Standards for New Energy Applications", and "New Energy Materials and Materials and Installation Specifications in Different Regions" and so on.

4. Conclusion

As an important energy consumption project for social and economic development, civil engineering consumes 30%~50% of the total energy consumption of the society With the expansion of the scale of the city, civil engineering projects are also increasing, for this is the current research hotspot, new energy as a new type of energy technology, can use light energy and hydropower in nature to generate electricity, can reduce the overall energy consumption of the same project, but some of it is questioned, this paper combines simulation techniques and

actual test situation analysis and finds that photovoltaic energy as an important content in the new energy can effectively save energy consumption, especially the energy of transportation and thermal insulation, etc., and can reduce its construction cost, the increase is 10%~6% in addition, new energy technology for the project, the construction period and different time periods will also have a corresponding impact difference, but the overall degree of impact is relatively stable, in addition, according to the relationship between energy consumption and cost of 1:5.2, it can be known that new energy for the reduction of energy consumption of civil engineering projects can also save construction costs, the saving rate is relatively high, with high social and economic benefits. There are also certain deficiencies in the research results, mainly reflected in data collection and temperature testing, and the amount of data involved in the project is larger and more complex, and I use the simplified method of subjective and objective separation, and will analyze a certain item in the air in the future, so as to improve the effectiveness of the analysis.

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