Correlation Evaluation and Optimization of Greenhouse Gas Emissions and Electricity Energy Consumption

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Abstract: The relationship between greenhouse gas emissions and electricity consumption is deeply interconnected. The generation and utilization of electric energy, particularly from non-renewable sources such as coal, oil, and natural gas, significantly contribute to the release of greenhouse gases, exacerbating the global climate crisis. To address this pressing issue, it is crucial to optimize electricity consumption and promote the use of renewable energy sources.One key strategy is to encourage the development and utilization of renewable energy. Solar, wind, and hydro power offer sustainable alternatives to fossil fuels, reducing our reliance on them and subsequently decreasing greenhouse gas emissions. Governments can play a pivotal role by formulating policies and implementing incentives to drive increased investment and adoption of renewable energy technologies.Improving energy efficiency is another vital aspect. Enhancing the efficiency of power equipment and systems, as well as reducing overall energy consumption, can effectively reduce greenhouse gas emissions. Real-world data from residential areas demonstrates the potential impact of such improvements. For instance, in 2017, residential electricity consumption amounted to 810KW·h, resulting in greenhouse gas emissions of 5.8 million cubic meters. However, by 2022, with the gradual integration of renewable energy sources, residential electricity consumption increased to 2320KW·h, while greenhouse gas emissions were reduced to 3.1 million cubic meters.In conclusion, optimizing electricity consumption is essential in mitigating greenhouse gas emissions and combating climate change. It requires collaborative efforts from governments, businesses, and individuals to implement appropriate policies and measures that promote the development of clean energy sources and improve energy efficiency. By doing so, we can effectively reduce greenhouse gas emissions and achieve sustainable development.

Keywords: process optimization, energy consumption, renewable energy, greenhouse gases, electric energy

1. Introduction

Against the backdrop of increasingly severe global climate change issues, accurately quantifying greenhouse gas emissions has become the key to climate change research

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and policy formulation c1]. The greenhouse gases and aerosols emitted by humans are the main factors causing global climate warming and atmospheric environmental degradation [2]. With the increasing attention paid to global climate change, terms such as greenhouse gases, energy conservation and emission reduction, and low-carbon living have begun to appear frequently in front of the public. In the general understanding of the public, carbon dioxide is the main greenhouse gas and the culprit leading to global climate change [3]. It can be seen that reducing regional energy consumption intensity is of great significance for effectively promoting energy conservation and emission reduction [4]. High-quality development of green energy is an important organic component of green and high-quality development [5]. It is necessary for enterprises to pay attention to energy consumption quotas in order to achieve healthy and sustainable development [6]. The concept of zero energy consumption has become a major concept in the development of various industries today [7]. The focus is on analysing and optimising the relationship between greenhouse gas emissions and electricity energy usage.

Scholarly study indicates that precise measurement of greenhouse gas emissions is essential to comprehending and adapting to global climate change. The primary contributors to both air environmental degradation and climate change are greenhouse gases and aerosols released by human activity. In order to encourage energy saving, emission reduction, and low-carbon living, regional energy consumption intensity must be decreased and green energy must be developed. Promoting sustainable development also involves getting businesses and the general public to pay attention to energy usage quotas. People may better accomplish green and high-quality development and help to create a sustainable future by examining and optimising the relationship between greenhouse gas emissions and electricity energy use.

2. Relationship between Greenhouse Gas Emissions and Electricity Energy Consumption

2.1 Contribution of Electric Energy to Greenhouse Gas Emissions

Building a green, low-carbon, safe, and reliable new type of power system is an important measure to address climate change and achieve sustainable development [8]. The production and use of electricity and energy have significant contributions to greenhouse gas emissions. With the continuous growth of global energy demand, The production and consumption of electricity play a significant role in greenhouse gas emissions, making it a key focus in addressing climate change. Various methods of power generation, including coal-fired, natural gas, nuclear, and renewable energy, all have different impacts on greenhouse gas emissions. Additionally, the use of electricity itself can indirectly contribute to these emissions. Therefore, it is essential to understand the relationship between electricity production, consumption, and greenhouse gas emissions to develop effective strategies for reducing emissions and promoting sustainable development.The green development of the power energy system is related to the sustainable development of economic activities [9].

The power energy system is a complex system with multiple stakeholders [10], and the production and use of power energy make significant contributions to greenhouse gas emissions. There are mainly the following aspects:

Coal-fired power generation is a prominent method of electricity production, but it is a significant source of greenhouse gas emissions as well. Significant volumes of carbon dioxide (CO2), sulphur dioxide (SO2), and nitrogen oxides (NOx) are released during the burning of coal, and these emissions have a negative impact on air quality and climate change. The various CO2 emission sources' emission ratios are shown in Figure 1.

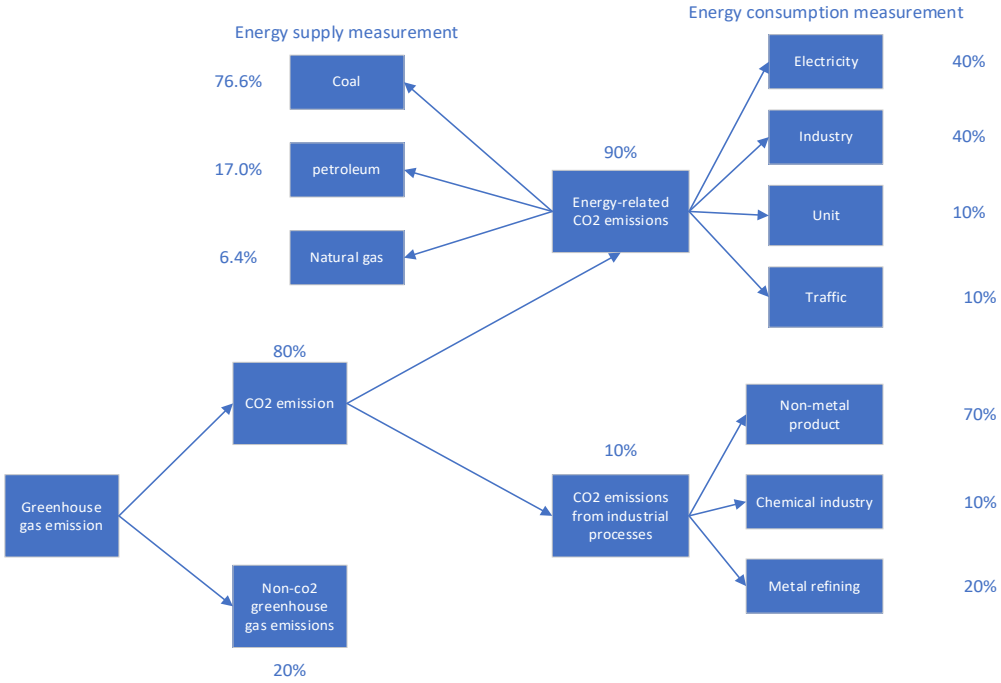

Fig.1 Ratio of CO2 emission modes

Natural gas power generation is considered a cleaner alternative to coal, as it produces lower carbon dioxide emissions. However, it still contributes to greenhouse gas emissions, and there is a risk of methane leaks during the extraction and transportation of natural gas. Methane is a powerful greenhouse gas that warms the planet more than carbon dioxide.

Nuclear power generation is often regarded as a low-carbon energy source, as it does not directly emit greenhouse gases during operation. However, the process of nuclear power generation produces radioactive waste, and the management and

storage of this waste can result in the release of greenhouse gases.

Since renewable energy sources like solar, wind, and hydro power generate very little greenhouse gas emissions, they are regarded as ecologically beneficial.. However, the availability and reliability of renewable energy sources are influenced by weather conditions and geographical factors. Despite their benefits, the global share of renewable energy in the overall energy mix remains relatively low.

Power generation from renewable energy: Techniques including solar, wind, and hydropower essentially produce no greenhouse gas emissions.. However, the power generation of renewable energy is limited by weather and geographical conditions, and its proportion in the global energy structure is still relatively low.

Electricity usage: The use of electricity can also have an impact on greenhouse gas emissions. For example, vehicles that heavily use electricity (such as electric vehicles) can reduce exhaust emissions, but if electricity is generated from coal, there would still be indirect greenhouse gas emissions.

Electricity energy interconnection technology plays a crucial role in promoting energy imports, reducing environmental pollution, and improving energy utilization efficiency [11]. Analysis reveals that in order to lower the amount that electricity use and production contribute to greenhouse gas emissions, energy management and regulation must be strengthened, the use of clean energy must be encouraged, and energy utilisation efficiency must be improved.

2.2 Power Energy Greenhouse Gas Emissions Process

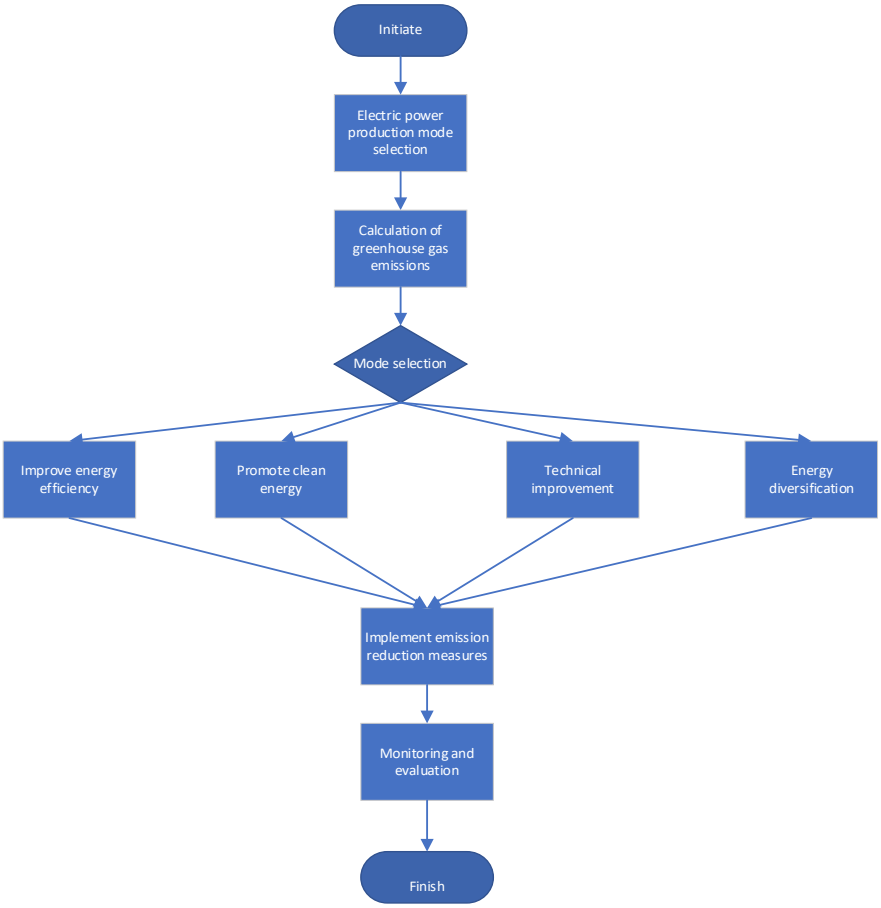

Fig.2 Flow chart of greenhouse gas emissions from electric energy

Realizing net zero emissions of greenhouse gases and solving global environmental problems has become a consensus among countries around the world. Standards are an important technical approach to promote deep greenhouse gas emissions reduction [12]. However, in the context of global climate change, greenhouse gas emissions have had a serious impact on the Earth's environment and human society. The production and use of electric energy is one of the important sources of greenhouse gas emissions. The correlation between electricity energy and greenhouse gas emissions is shown in Figure 2.

Process optimization has made significant progress in many aspects [13]. By

developing emission reduction strategies and implementing relevant measures in Figure 2, the contribution of electricity energy to greenhouse gas emissions can be reduced, making a positive contribution to addressing global climate change. However, emission reduction efforts require sustained efforts and global cooperation to ensure sustainable development and the health of the earth's ecosystem.

3. Correlation and Improvement between Greenhouse Gas Emissions and Electricity Energy Consumption

3.1 Correlation between Greenhouse Gas Emissions and Electricity Energy Consumption

The issue of greenhouse gas emissions has garnered significant attention due to its detrimental impact on the environment. It has become imperative for businesses to calculate and monitor these emissions as a fundamental task in their efforts towards energy conservation and emission reduction [14]. The consumption of electricity is closely linked to greenhouse gas emissions, and as global energy demand continues to rise and concerns about environmental pollution and climate change intensify, understanding the relationship between electricity consumption and greenhouse gas emissions has become increasingly crucial. The production and utilization of electrical energy often serve as major contributors to greenhouse gas emissions, particularly in regions heavily reliant on traditional coal-fired and oil-fired power generation. Therefore, gaining a comprehensive understanding of the correlation between electricity consumption and greenhouse gas emissions is vital for the development of effective energy policies and the reduction of greenhouse gas emissions. This paper aims to provide a comprehensive explanation of this relationship.

Over the past century, the significant warming of the Earth's climate has had a profound impact on the planet's surface systems where human beings reside [15]. Greenhouse gas emissions are mostly caused by the production and use of electrical energy, particularly when electricity is generated using conventional energy sources like coal and oil. A thorough description of the relationship between greenhouse gas emissions and electricity energy consumption may be found in the sections that follow:

Oil- and coal-fired electricity generation: Although coal-fired and oil-fired power plants are widely used to generate electricity, during the combustion process they emit significant volumes of greenhouse gases, including carbon dioxide. Since coal is one of the fossil fuels with the highest carbon content, coal-fired power generation is one of the primary causes of greenhouse gas emissions worldwide. The combustion of fuels to create electricity also releases large volumes of nitrogen oxides and carbon dioxide into the air.

When it comes to power generation, natural gas is often regarded as a cleaner alternative compared to coal and oil. Natural gas combustion produces lower greenhouse gas emissions, particularly carbon dioxide, compared to coal and oil.

Additionally, natural gas power generation results in minimal emissions of particulate matter and sulfur oxides. As a result, natural gas power generation is considered a relatively cleaner method of producing electricity.

Renewable energy generation: Renewable energy sources such as wind, solar, and hydro power generate almost no greenhouse gas emissions. The utilization of these energy sources is an important way to reduce greenhouse gas emissions. By scaling up the development and utilization of renewable energy, the power industry's dependence on traditional energy can be significantly reduced, thereby reducing greenhouse gas emissions.

Energy efficiency: Improving energy efficiency is another important strategy for reducing greenhouse gas emissions. By adopting more efficient power generation technologies and equipment to minimize energy waste, greenhouse gas emissions can be reduced while still meeting energy demands.

Energy transformation: Reducing greenhouse gas emissions requires promoting energy transformation. Greenhouse gas emissions in the power sector may be greatly decreased by progressively shifting away from old energy sources and towards clean, renewable energy. Energy usage is a topic that society is becoming more aware of. [16], and careful analysis reveals a strong correlation between greenhouse gas emissions and electricity energy consumption. Conventional methods of power generation, such as coal-fired and oil-fired plants, are major contributors to greenhouse gas emissions. Conversely, the utilization of renewable energy sources and the enhancement of energy efficiency play vital roles in reducing these emissions. By promoting the transition towards cleaner energy sources and implementing measures to enhance energy efficiency, greenhouse gas emissions in the power industry can be effectively mitigated, thus contributing to the global efforts to address climate change. In order to develop effective energy policies and foster sustainable development, it is imperative to conduct comprehensive research and gain a deeper understanding of the relationship between greenhouse gas emissions and electricity energy consumption.3.2 Advantages of Using Renewable Energy

With the rapid development of the social economy, there are also significant issues in the energy situation, such as consumption and environmental pollution [17].In response to the escalating global energy demand and growing concerns about climate change, the adoption of renewable energy is increasingly recognized as a pivotal strategy to address energy and environmental challenges. Renewable energy encompasses a range of sources that are perpetually replenished by nature, including solar, wind, hydro, geothermal, and biomass energy. In contrast to conventional energy sources, renewable energy offers numerous advantages. It not only fulfills our energy requirements but also diminishes reliance on finite resources, thereby enhancing environmental quality. Additionally, renewable energy sources contribute to the reduction of greenhouse gas emissions, promote sustainable development, and foster energy independence. and promoting economic development. The summary of four representative resources is shown in Figure 3.

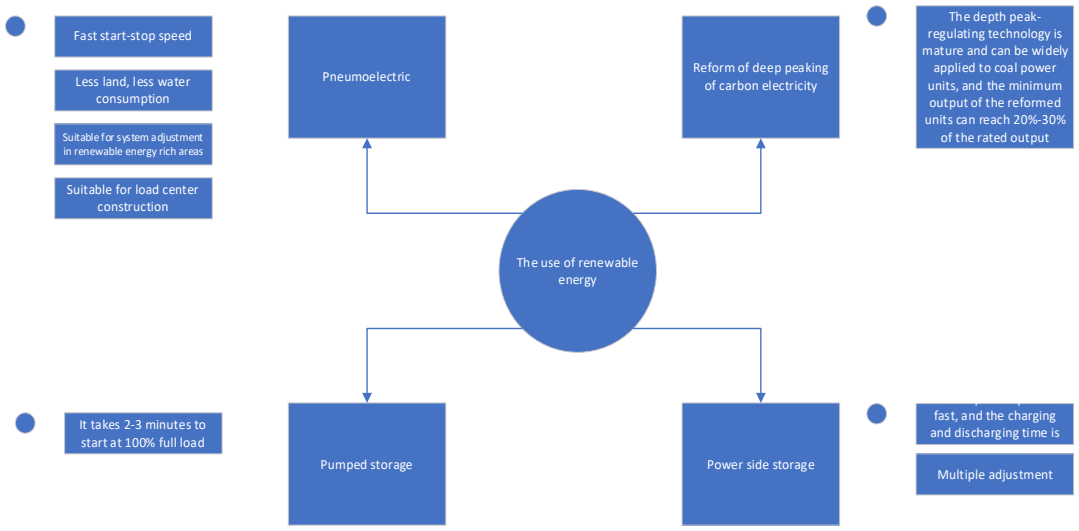

Fig.3 Advantages of using renewable energy

As the economy continues to grow, there is an increasing demand for the utilization of green energy[18].. Figure 3 analysis reveals the multiple advantages of renewable energy utilization.Firstly, the utilization process of renewable energy produces almost no greenhouse gas and pollutant emissions, which causes less environmental pollution and is beneficial for protecting the health of ecosystems. Secondly, renewable energy has sustainability, which can meet long-term energy needs and reduce dependence on limited mineral energy. In addition, the diversified utilization of renewable energy has reduced dependence on a single energy source and improved the security and stability of energy supply.

3.2 Correlation Process between Greenhouse Gas Emissions and Electricity Energy Consumption

Green development is the development direction of world energy resources energy [19], and the relationship between room gas emissions and power energy consumption is also an important environmental issue. With the continuous growth of global energy demand, the power industry has become one of the main sources of greenhouse gas emissions. Different power generation methods have different impacts on the generation of greenhouse gases, and improving energy efficiency and adopting renewable energy are key ways to reduce greenhouse gas emissions, as shown in Figure 4.

Green energy development is an important strategy for countries around the world to address energy scarcity, ensure energy supply, and achieve long-term sustainable development [20]. Based on the analysis of the flowchart in Figure 4, it can be seen that improving energy efficiency is important, and some strategies to reduce

greenhouse gas emissions are introduced. From Figure 4, it can be seen that understanding the relationship between indoor gas emissions and electricity energy consumption can lead to the development of more environmentally friendly and sustainable energy policies.

4. Formulas and Experiments

4.1. Formula

Greenhouse gas emission formula:

$$E = P \times F \tag{1}$$

In Formula (1), E represents the greenhouse gas emissions, which is the total amount of greenhouse gases generated during the power generation process per unit of time. Greenhouse gases include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and others, which have significant impacts on global climate change.

P represents the amount of electricity generated, which is the energy consumption of electricity per unit time. It can be expressed in GWh or other appropriate units, reflecting the level of activity and energy demand of the power industry.

F represents the emission factor, which is a proportional coefficient used to measure the greenhouse gas emissions generated per unit of electricity generation. Different power generation methods and fuel types would have different emission factors. For example, coal-fired power generation typically has higher emission factors, while renewable energy sources such as solar and wind power have lower emission factors.

Optimization objective function:

$$O = \alpha E + \beta P \tag{2}$$

O represents the optimization objective function, which is an indicator that comprehensively considers greenhouse gas emissions and energy consumption. By adjusting the weight coefficients α and β, the relative importance of greenhouse gas emissions and energy consumption in the optimization objectives can be controlled.

α and β are weight coefficients that are used to adjust the relative weights of greenhouse gas emissions and energy consumption in optimization goals. By adjusting the size of these weight coefficients, the importance of reducing greenhouse gas emissions or energy consumption can be determined based on actual needs and priorities.E represents greenhouse gas emissions, as defined in the above formula.P represents the power generation, which is the same as the definition in the above formula.

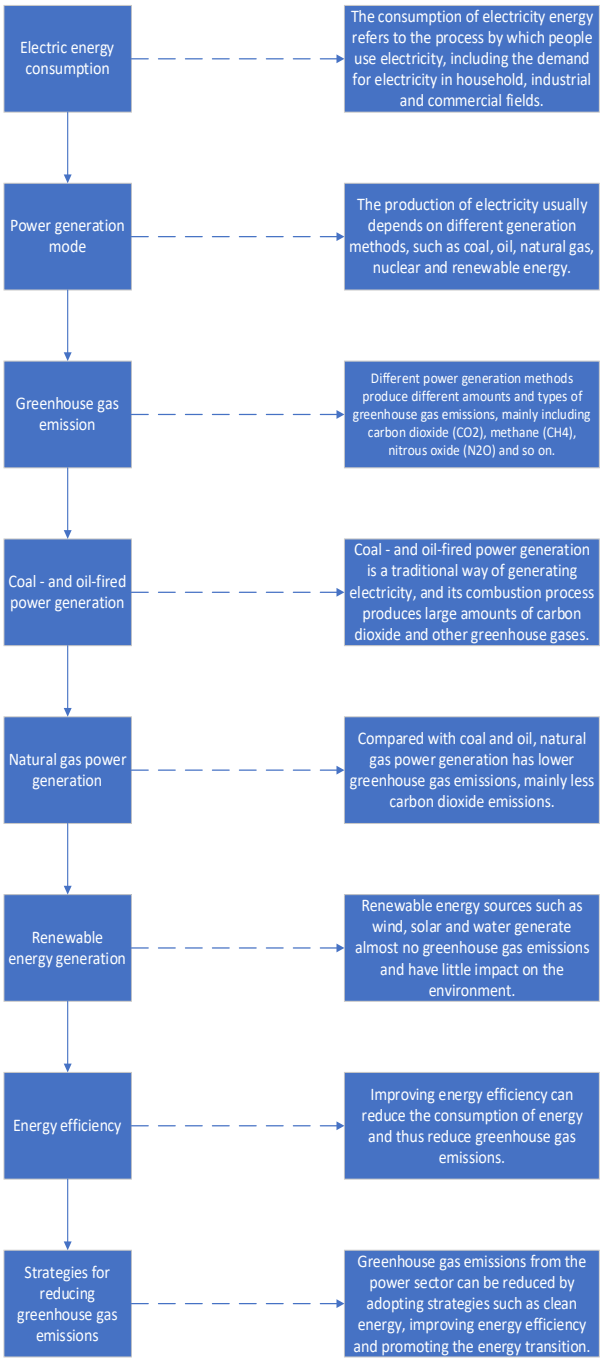

Fig.4 Association flow chart

By optimizing the objective function, a balanced solution can be found, which is to minimize energy consumption while reducing greenhouse gas emissions. Such a plan helps to achieve the goals of sustainable development and addressing climate change.

4.2. Correlation Experiment between Greenhouse Gas Emissions and Electricity Energy Consumption

One plot was randomly selected as the experimental subject. The experimental subjects gradually used electricity generated from renewable energy for 6 years to ensure sufficient data was collected for analysis. A comparison between electricity energy consumption and greenhouse gas emissions was established by gathering data on residential areas' energy consumption and emissions of greenhouse gases between 2017 and 2022. The experimental data is shown in Figure 5.

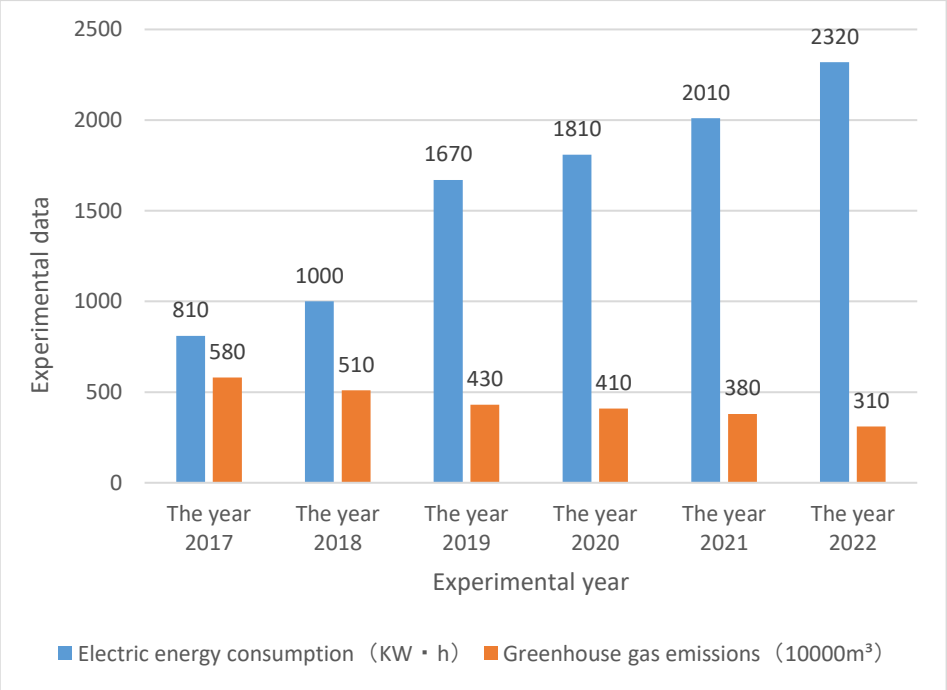

Fig.5 Experimental data on the correlation between greenhouse gas emissions and electricity energy consumption

Based on the summary of experimental data in Figure 5, the following conclusions can be drawn:

Within the observed time range (2017 to 2022), electricity energy consumption has shown an increasing trend year by year, while greenhouse gas emissions have shown a decreasing trend year by year.

During the period from 2018 to 2022, the increase in electricity energy consumption was relatively significant, while the reduction in greenhouse gas emissions was relatively small. In 2017, the use of electric energy reached 810KW·h (kilowatt hour), with greenhouse gas emissions reaching 5.8 million cubic meters. In 2022, the use of electric energy reached 2320KW·h, while greenhouse gas production decreased to 3.1 million cubic meters.This highlights the significant role of renewable energy in reducing greenhouse gas emissions in the electricity sector.

5. Conclusions

Numerous studies have examined the connection between greenhouse gas emissions and electric energy use, and the results show that the two are highly correlated. Empirical evidence consistently indicates that there is a positive correlation between power use and greenhouse gas emissions. This emphasises how crucial it is to optimise energy use in order to successfully lower greenhouse gas emissions.Given this, it is imperative that we keep encouraging the creation and application of renewable energy sources. In addition to lowering dependency on fossil fuels, renewable energy sources like solar, wind, and hydro power also dramatically cut greenhouse gas emissions. By putting laws and incentives in place that motivate investors and companies to raise the percentage of renewable energy in their energy mix, governments may play a crucial role.Reducing greenhouse gas emissions also requires increasing energy efficiency. Significant reductions in greenhouse gas emissions can be attained by increasing the efficiency of power systems and equipment and putting energy-saving measures in place. Governments, corporations, and people must work together to prioritise energy efficiency and implement sustainable practises.. To sum up, reducing greenhouse gas emissions and tackling climate change require optimising power use. To design suitable laws and measures that support the growth of renewable energy sources and enhance energy efficiency, businesses, citizens, and governments must work together. In order to lower energy consumption and greenhouse gas emissions, this involves promoting technical innovation, bolstering energy management procedures, and offering incentives for the use of renewable energy. Sustainable development may be accomplished via these coordinated efforts, improving the environment and making it healthier for coming generations.

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