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Analysis of the Impact of Smart Energy Transformation and Energy System Optimization on Teachers' Psychology and Teaching Environment

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Abstract. This study focuses on the far-reaching effects of smart energy transition and energy system optimization on teachers' mental health and teaching environment. An analytical model that fits our national context was developed to compare the performance of traditional and smart energy systems with experimental data and related literature, using the unit teaching area as the functional unit. The results show that the optimization of the smart energy system resulted in a 40.7% reduction in energy consumption and significant reductions in VOC (31.5%), NOx (15.2%), SO_2 (66.7%), and GHG (55.8%) emissions. These environmental improvements directly contribute to a cleaner and healthier teaching environment and reduce the adverse effects of air pollution on teachers' physical health, thereby improving their mental health and overall job satisfaction. The study found that the pollutant emissions from the smart energy system decreased significantly, with emissions of VOC, NOx, SO_2, PM10, and CO decreasing by 41.5%, 49.5%, 56.0%, 20.7%, and 7.9%, respectively, and emissions of the greenhouse gases N_2O, CH_4, and CO_2 decreasing by 6.5%, 55.9%, and 56.3%, respectively. These significant improvements mean that the air quality in the teaching environment will be significantly better, thereby reducing the health problems, such as respiratory illnesses and allergic reactions, that teachers suffer from as a result of prolonged exposure to air pollutants. A healthier working environment not only reduces the risk of illness but also effectively reduces teachers' psychological stress due to health problems and enhances their motivation and engagement at work. For teachers, this improved environment helps to create a more supportive work atmosphere where they feel that their health and professional needs are valued and protected, and this sense of security plays an important role in reducing work stress and improving professional identity. Therefore, the application of the smart energy system is not only a transformation of the school's energy management approach but also a positive contribution to teachers' mental health and working environment, which is of great practical significance.

Key words. Smart Energy Transformation, Teacher Psychology, Energy System Optimization, Teaching and Learning Environment.

1. Introduction

With the continuous advancement of global smart energy transformation, growing energy demand has led to increasing shortages and rising prices of non-renewable energy [1]. At the same time, the consumption and emissions of traditional energy have had a serious impact on the environment, forcing governments and relevant institutions to strengthen their efforts to renewable energy. Research and application [2], [3]. The optimization of smart energy systems has become a key path to improve energy utilization efficiency and reduce environmental impact, and its application in the teaching environment has gradually received attention [4], [5]. Smart energy systems can achieve efficient energy management and optimization in the built environment. Through the combination of intelligent control technology and clean energy, they reduce energy consumption and pollutant emissions within the campus and improve the air quality and comfort of the teaching environment, thus having a positive impact on teachers' mental health [6], [7]. This transformation will not only help alleviate the tension of energy supply but also effectively reduce dependence on fossil fuels and provide a more stable and sustainable energy supply. The optimization design of a smart energy system focuses on using low-cost, clean electricity from the power grid to maximize the utilization of energy [8], [9]. By integrating renewable energy sources, such as solar energy, wind energy, and geothermal energy, and cooperating with energy storage and intelligent control technology, supply and demand can be effectively balanced, and energy allocation can be optimized. Compared with traditional energy systems, the application of smart energy systems in educational environments can reduce a large number of harmful emissions, such as volatile organic compounds (VOC), nitrogen oxides (NOx), sulfur dioxide (SO_2), which is important for reducing classrooms [10], [11]. It has significant effects on air pollution, improving teachers' work efficiency and psychological comfort.

Traditional energy systems have limited degrees of optimization, and their energy conversion efficiency and environmental performance are poor [12]. In contrast, smart energy systems can make cleaner and more efficient use of electricity, reduce dependence on traditional fossil fuels, and significantly reduce emissions. Based on this premise, smart energy systems have been increasingly applied and promoted in public buildings such as schools [13], [14]. Smart energy systems also have greater flexibility and adaptability and can be adjusted under different energy needs to achieve the goals of minimizing energy consumption and maximizing efficiency. Against the current background of prominent global energy and environmental issues, countries are actively promoting the research and application of smart energy technology and regarding it as an essential development direction of future energy systems [15], [16]. The comprehensive benefit evaluation of smart energy systems includes a systematic analysis of energy consumption and pollutant emissions throughout the energy life cycle. Traditional energy system evaluation is often limited to the use stage, ignoring the energy consumption and environmental emissions of upstream production links [17], [18]. This paper comprehensively analyzes the application of smart energy systems in the teaching environment by using the life cycle assessment method and evaluates its actual impact on teachers' psychology and teaching environment from the perspective of the whole life cycle of energy. Life cycle assessment is widely recognized internationally [19].

2. Smart Energy Transformation and Campus Energy System Optimization

A. Campus Environmental Energy System

The energy system in the campus environment includes many aspects, such as power supply, heating, cooling, and lighting. The efficient operation of these systems is directly related to the daily teaching and management activities of the school. Equation (1) demonstrates the overall strategy for optimizing the campus energy system.

$$MCC_s = \sum_{i=1}^{L} \left(EMSU_{s,j} \times EC_i \right) \tag{1}$$

By introducing advanced smart grid technology, energy storage systems, LED lighting, and other energy-saving equipment. Equation (2) demonstrates how the efficient use and intelligent management of energy on campus can be achieved to create a more comfortable and sustainable learning and working environment for teachers and students.

$$MC_s = MCC_s + CP_s \tag{2}$$

The application of smart grid technology can automatically adjust power distribution according to changes in power demand on campus. The dynamic adjustment capability demonstrated in equation (3) reduces power wastage, equalizes power loads during peak periods, and reduces energy costs for schools.

$$\mathrm{EFS_s = MC_s / CF_s} \tag{3}$$

Smart grids also have data collection and analysis functions, which can monitor and optimize energy usage patterns in real-time to ensure the rational allocation of power resources. Equation (4) demonstrates that this energy system reduces unnecessary power consumption and improves the efficiency and safety of energy use, providing a strong guarantee for the stable operation of the campus.

$$EFS_s = CP_s / CF_s \tag{4}$$

Energy storage systems also play a key role in campus energy management. The energy storage system can store excess electric energy when power demand is low and release electric energy when demand is peak to ensure the stability of the power supply. As shown in Equation (5), this energy storage mechanism can not only help schools reduce electricity costs but also cope with sudden power interruptions or unstable power supply.

$$EMSCCC_{s,j,j} = \sum_{k=1}^{N} \left(PS_{s,j,k} \times EF_{i,j,k} \right) \tag{5}$$

Ensure the continuous operation of critical facilities on campus. As shown in equation (6), the energy storage system can also be combined with renewable energy such as solar energy and wind energy to provide more environmentally friendly energy options for the campus, help reduce the school's carbon emissions and achieve the goal of a green campus.

$$EMSCC_{s,i,j} = EPS_{s,j} \times EMSCCC_{s,j,j} \tag{6}$$

B. Energy System Optimization Management Strategy

The management strategy of energy system optimization is the key to building a green campus and achieving sustainable development. These strategies cover many aspects, such as energy audit, deployment of intelligent control systems, optimization of building design, and promotion of the use of renewable energy. As shown in equation (7), each measure has targeted improvement of the efficiency and effectiveness of school energy management.

$$EMSC_{s,j} = \sum_{j=1}^{M} EMSCC_{s,i,j} \tag{7}$$

As a basic measure of energy system optimization, energy audits can help schools identify waste and inefficient links in energy use. Through a detailed energy audit, as shown in formula (8), the school can clarify the energy consumption of each building and facility, find high-energy-consuming equipment and unnecessary energy consumption sources, and thus provide a scientific basis for formulating targeted energy-saving improvement plans.

$$EMS_{s,j} = EMSU_{s,j} + EMSC_{s,j} \tag{8}$$

The audit results may show that the lighting system of some old buildings consumes too much electricity or the energy efficiency of some heating and cooling equipment is low. As shown in Equation (9), this information can guide schools to make critical renovations and minimize energy waste.

$$EP_s = C_s / CP_s = C_x / CP_s \tag{9}$$

The deployment of the intelligent control system is an essential means to optimize the campus energy system. The intelligent control system can automatically adjust and monitor various energy equipment on campus in real-time, as shown in equation (10), such as automatically adjusting the running status of air conditioning, heating, and lighting according to actual needs.

$$EF_s = EP_s \times EFS_s \tag{10}$$

This automated management method not only reduces human errors and energy waste but also achieves accurate energy consumption control and improves energy efficiency. As shown in equation (11), the intelligent control system can also integrate the energy data on campus for data analysis and prediction, thereby optimizing the energy management strategy and further improving the energy-saving effect.

$$EPC_{s,j} = EP_s \times EPS_{s,j} \tag{11}$$

Optimizing architectural design is essential to achieve long-term optimization of campus energy systems. By improving the thermal insulation performance of the building, such as the use of thermal insulation materials on the walls and roofs, as shown in equation (12), the energy consumption of heating in winter and cooling in summer can be significantly reduced.

$$EFUP_s^{'} = C_X / CF_1 = C_X / CPP^t \tag{12}$$

3. Analysis of the Influence of Teaching Environment and Teacher Psychology under the Background of Energy Optimization

A. Analysis of the Influence of Teaching Environment

In the context of smart energy transformation and energy system optimization, the psychological empowerment model can be used as a reference to analyze the impact of these changes on teachers' psychology and teaching environment [20], [21]. Based on the psychological empowerment process model proposed by Conger and Kanungo, the smart energy transition not only improves the campus environment at the technical and physical levels but may also profoundly affect teachers' psychological state and teaching experience [22], [23]. First of all, teachers will preliminarily judge their feelings and role positioning in the working environment based on the optimization of the campus energy system and smart energy transformation measures [24], [25]. For example, when schools adopt intelligent control systems, energy-efficient lighting, and renewable energy, teachers may feel that the environment has become more comfortable. At the same time, they perceive the school management's emphasis on sustainability and the health of teachers and students [26], [27]. This feeling stems from the change in the school's working environment, which in turn affects teachers' psychological state and motivation. Figure 1 is a psychostatic analysis diagram of primary and secondary school teachers. In this process, teachers may be aware of some inconveniences and stressors in their past work, such as unstable indoor temperatures and insufficient lighting caused by low energy efficiency [28], [29]. These factors often affect teaching quality and teachers' mental health. In the process of smart energy transformation, these problems have been improved through energy-saving renovation and intelligent management on campus, thus enhancing teachers' job satisfaction and psychological security [30].

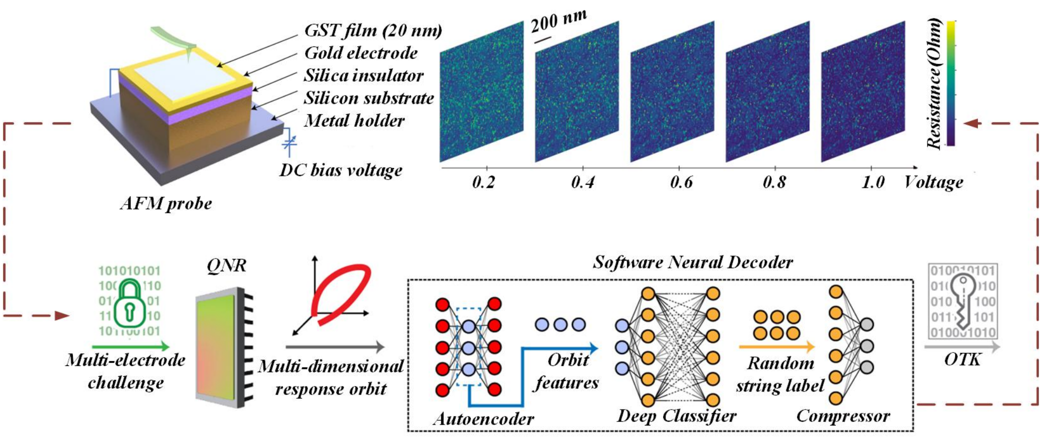

Figure 1. Psychological Static Analysis Chart of Primary and Secondary School Teachers

Next, teachers may feel a greater sense of autonomy and participation by participating in energy management or related decision-making processes in schools. For example, schools may invite teachers to participate in discussions on campus energy management through feedback mechanisms and suggestion collection. This kind of participation can not only enhance teachers' sense of identity in school decision-making but also make them feel the promotion of their value and power, thus promoting teachers' psychological empowerment. With the gradual improvement of smart energy systems, teachers' self-efficacy will also be improved. They may experience a more stable and comfortable teaching environment, and these changes can reduce the fatigue and stress associated with adverse environments and enhance their confidence in the effectiveness of teaching. At the same time, the school conveys a positive work culture and values to teachers through energy conservation and sustainable development projects, making it easier for teachers to internalize these positive signals into their professional goals and motivations. The environmental and psychological changes brought about by the smart energy transition will affect teachers' behavioral performance. They may participate more actively in various school activities and show higher teaching enthusiasm and a stronger sense of professional belonging. At the same time, this transformation may also promote teachers to maintain high initiative and persistence in their work, thus improving the overall teaching quality and student experience.

B. Teaching Environment and the Function of Teachers' Psychology

When analyzing the impact of smart energy transformation and energy system optimization on teachers' psychology and teaching environment, Bandura's social cognition theory and self-efficacy theory can be used for reference. The social cognitive theory emphasizes the ternary interaction among the environment, individual internal factors, and behavior, which are independent and interact with each other to form a dynamically changing whole. This theory provides a theoretical basis for the study of self-efficacy. Figure 2 is a deep-play diagram of psychological empowerment and professional optimism. According to the theory of self-efficacy, an individual's belief or self-perception about one's competence is a form of social cognition, which will be influenced by his environment and constantly changes through the interaction with his behavior. In the campus environment, changes in the external environment, such as smart energy transition and energy system optimization, will affect teachers' psychological state and work performance. For example, improved classroom lighting, indoor temperature control, and a more stable energy supply can make teachers feel more comfortable and efficient in the teaching process, thus enhancing their confidence in their teaching ability and self-efficacy.

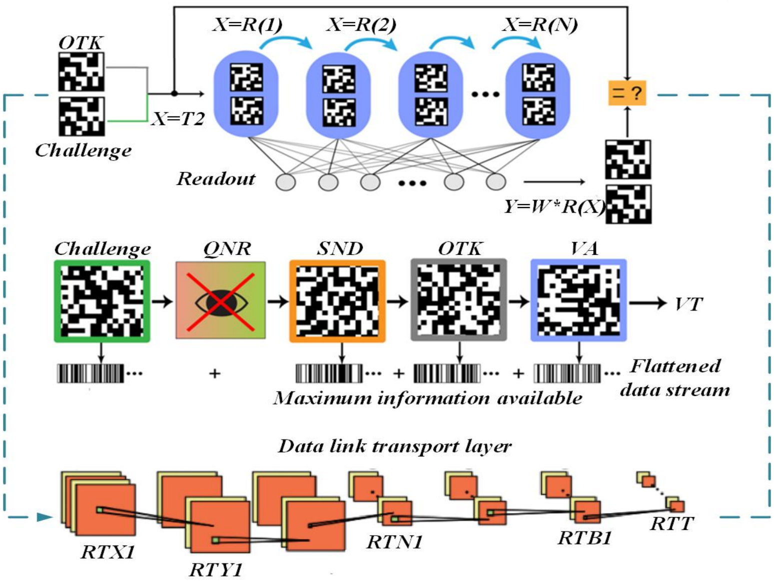

Figure 2. Psychological Empowerment and Professional Optimism Deep Playing Chart

Teaching efficacy is the concrete embodiment of self-efficacy in the field of education. It is not just a belief; it is also an ability which reflects the teacher's belief that he can achieve the desired goal in the teaching and learning process. In the context of smart energy system optimization, teachers' teaching effectiveness has felt a positive impact in many aspects. First of all, smart energy systems can provide a more stable and efficient teaching environment and reduce interference caused by energy problems, such as power outages, insufficient heating or excessive cooling. This improvement helps teachers focus on teaching tasks and boosts their confidence in their teaching abilities. Teachers' sense of teaching efficacy is also influenced by their observation of others' teaching performance and their own teaching experience. When teachers feel that the improvement of the school energy system makes their teaching environment more comfortable and supportive, their psychological state and emotional experience will also improve. Positive emotions and a healthy psychological state can increase teachers' self-confidence, stimulate their initiative and creativity in teaching, and further enhance their sense of teaching efficiency. Teachers may experience increased stress, anxiety, and dissatisfaction if they are in an undesirable work environment, such as frequent power outages, uncomfortable temperatures, etc. Suppose these negative emotions and psychological experiences exist for a long time. In that case, they may lead to the decline of teachers' self-confidence and doubt their abilities, thus hindering the improvement of teaching efficiency. Therefore, improving the management and optimization of the campus energy system can not only improve the physical environment but also have a profound impact on teachers' sense of teaching effectiveness by affecting their psychological state and emotional reactions.

4. The impact of Energy System Optimization and Smart Transformation on Teaching Environment and Teachers' Psychology

A. Energy System Optimization Management Strategy

Energy system optimization also needs to take into account non-combustion emissions in the process of energy extraction and utilization. For example, during coal mining, a large amount of methane (CH_4) will be released. Figure 3 shows an analytical diagram of the optimal management of the energy system, which is a greenhouse gas that is more potent than carbon dioxide. The adsorption amount of methane in coal seams before mining may reach 25 cubic meters per ton of coal, and non-combustion emissions such as volatile organic compounds (VOCs) and PM10 are also produced during coal washing. Similarly, methane emissions during crude oil extraction mainly come from direct emissions or flare combustion of unused oil field-associated gas. In contrast, large amounts of methane are released during natural gas extraction due to leakage and venting. During the mining process of these energy sources, the PM10 emissions produced by coal mining are relatively high, and the associated methane emissions are also the largest. Therefore, the contribution of coal mining to the greenhouse effect is significantly higher than that of crude oil and natural gas mining.

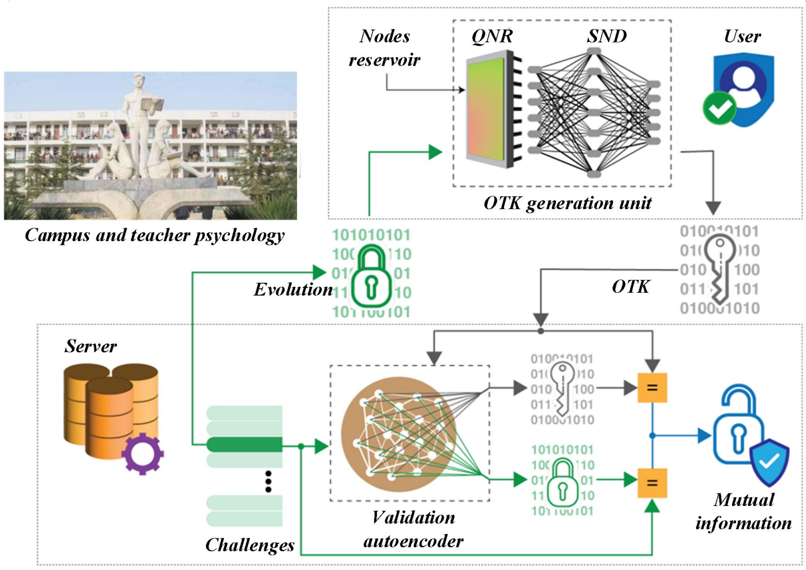

Figure 3. Energy System Optimization Management Analysis Diagram

Optimization strategies for campus energy systems can refer to international advanced practices, such as improving the utilization rate of coalbed methane to reduce direct methane emissions, thereby reducing the impact of the entire process on the greenhouse effect. At the same time, by optimizing the transportation links of the energy system, the emissions generated by energy in the life cycle can be effectively reduced. The main purpose of transportation analysis is to calculate the process fuel and emissions consumed during transportation when energy products per unit of heat are output. Factors affecting these data include the proportion of transportation modes, transportation distance, and fuel consumption during transportation. Energy system optimization also needs to pay attention to how to reduce the adverse impact on the environment and ensure that teachers can carry out their work in a good teaching environment. Effective energy management and transformation strategies can not only reduce energy use costs and improve resource utilization but also create a healthier and more sustainable teaching environment, thus having a positive impact on teachers' mental health and teaching results. Through these optimization measures, the carbon emissions of the campus can be reduced, the construction of a green campus can be promoted, and the job satisfaction of teachers and the learning experience of students can be further improved.

B. The Impact of Energy Transition on Teaching Environment and Teachers' Psychology

In the process of smart energy transformation and energy system optimization, it is necessary to scientifically assess the emission factors of different energy use systems to grasp their impact on the environment accurately. Currently, in campuses and educational environments, energy system optimization can draw on similar methods to calculate and analyze emission factors, thereby clarifying the emission characteristics of different energy systems and providing a scientific basis for smart energy transformation. Figure 4 is a map of the impact analysis of the energy transition on the teaching and learning environment. In China, the energy systems of most educational institutions mainly rely on traditional power supply and heating methods, and new technologies such as renewable energy and energy storage systems are gradually introduced. In this context, the optimization and emission analysis of the campus energy system should be based on the emission characteristics of the existing equipment. Similar to the emission factor analysis method of vehicles, a variety of means can be used to determine the emission factors of different energy systems. For example, in a power supply system, electricity comes from the power grid, and the energy composition of the power grid will directly affect its emission factors. If the power of the grid mainly comes from coal-fired power plants, its emission factor will be significantly higher than that of clean energy grids such as wind and solar energy. Therefore, by understanding the energy composition of the power grid, the emission factors of campus electricity consumption can be calculated.

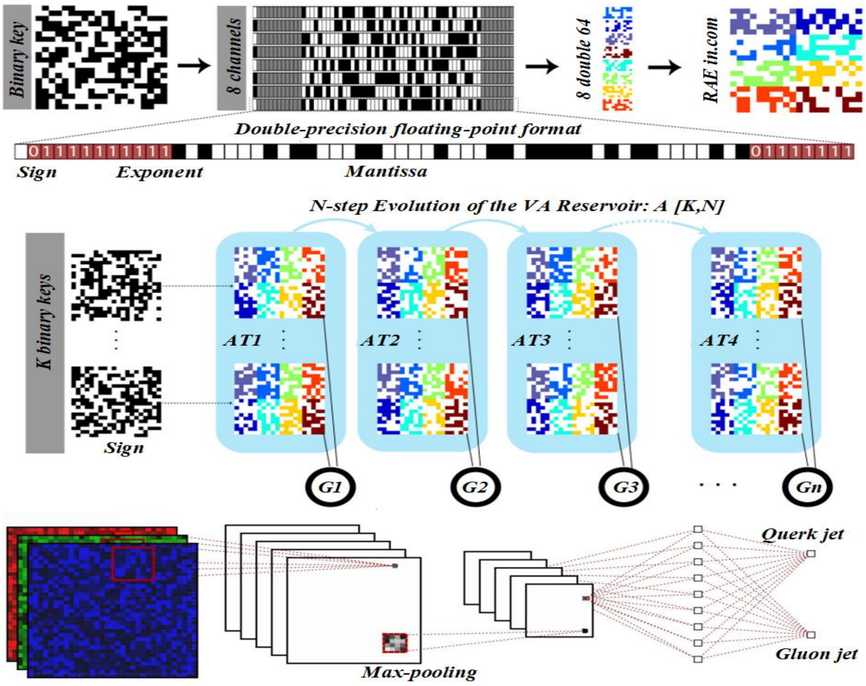

Figure 4. Map of the Impact Analysis of the Energy Transition on the Teaching and Learning Environment

The method of determining the emission factor of an energy system can be analogous to the road tunnel method. In the smart campus environment, this method can be used for reference to arrange sensor networks in the campus area to monitor the air quality and energy usage inside and outside different buildings so as to obtain emission data of the energy system under real-use conditions. The advantage of this method is that it can provide the emission level under the actual operation state and has high practical value. However, this method also has certain limitations, such as not being able to analyze the emission characteristics of a single energy device accurately. Computer modeling and simulation techniques can also be used to calculate the emission factors. For example, in the process of optimizing the campus energy system, a model calculation method similar to the transportation emission model can be used. By comprehensively considering factors such as equipment type, operating status, service life, load level, and environmental conditions of the energy system, a multi-factor emission factor calculation model can be constructed. At present, the widely used emission models in the world include MOBILE, PART5, EMFAC and COPERT, etc. The principles of these models are also applicable to the optimization analysis of campus energy systems. By using the calculation methods of these models for reference, the emission factors of the campus energy systems can be predicted and evaluated more accurately, thus providing a scientific basis for energy optimization. In the process of smart energy transformation, accurate emission factor analysis not only helps to identify high-emission sources and find optimization directions but also effectively evaluates the effectiveness of energy management strategies to ensure the green and sustainable development of the campus environment.

5. Experimental Analysis

In the process of smart energy transformation and energy system optimization, optimizing the energy consumption and emissions of the energy system on campus is a very critical link. According to the life cycle analysis of different energy systems, there are significant differences in the consumption and emission characteristics of different energy sources. Figure 5 shows the energy consumption diagram of the PHEV fuel cycle. In the existing campus energy consumption structure, the proportion of conventional fuel consumption is relatively high. By introducing more renewable energy and improving energy conversion efficiency, the use of traditional energy and greenhouse gas emissions can be significantly reduced.

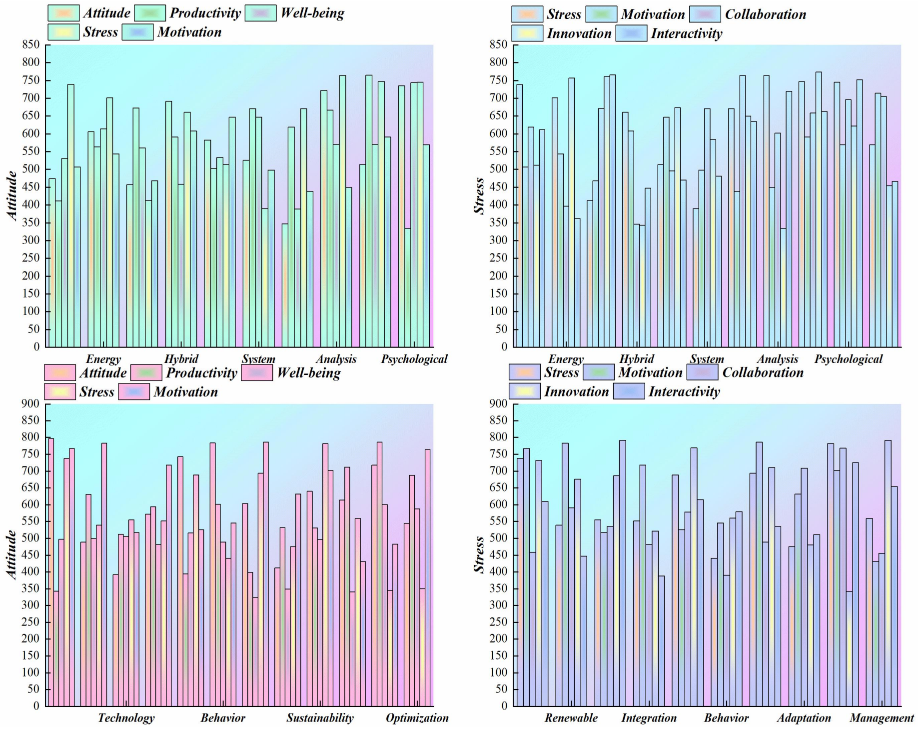

Figure 5. PHEV Fuel Cycle Energy Consumption Map

Utilizing advanced smart grids and energy storage systems through more efficient energy management can effectively reduce total energy consumption and reduce dependence on traditional high-emission energy sources such as coal and oil. According to the data, if clean electricity can be used to a greater extent on campus, Figure 6 shows the energy conversion efficiency and greenhouse gas reduction ratio, and its energy consumption and carbon emissions will be significantly reduced. Optimizing electricity sources, such as reducing the proportion of coal power in the grid structure, can significantly reduce energy consumption and greenhouse gas emissions while improving the overall energy conversion efficiency, which is very important to achieve the goal of a green campus.

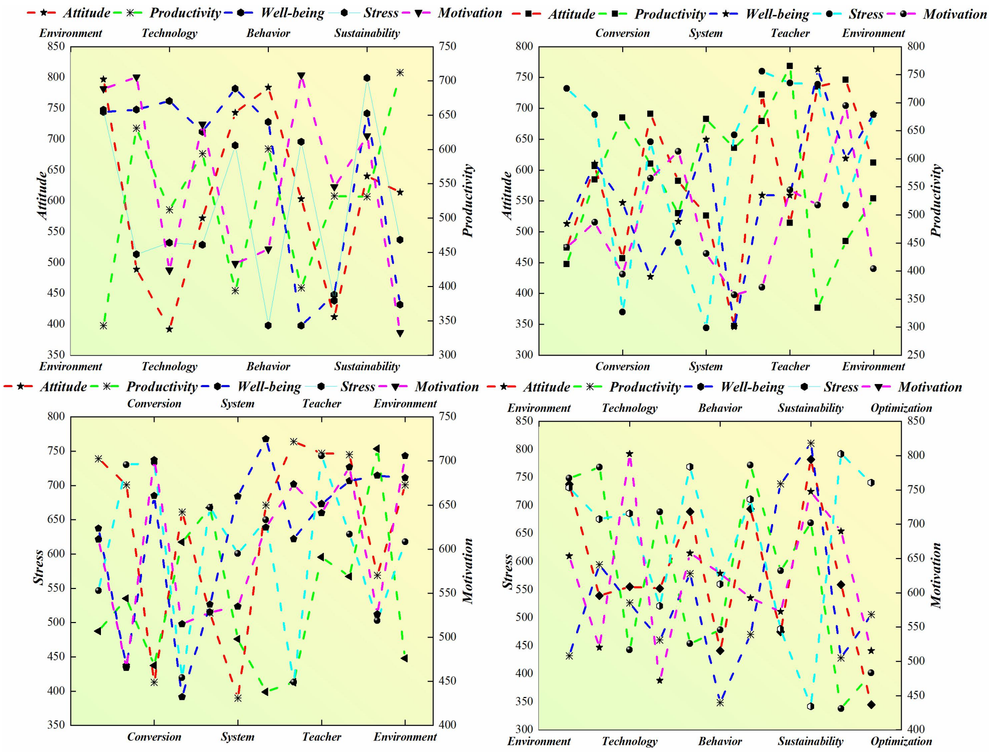

Figure 6. Energy Conversion Efficiency and Greenhouse Gas Reduction Ratio Diagram

The key to the optimization strategy is to improve the energy conversion efficiency of the power generation process and reduce the proportion of coal power. Figure 7 is a crude oil consumption diagram of the fuel cycle and introduces more renewable energy sources, such as wind energy and solar energy. This can not only reduce the total consumption of the energy system but also effectively control gas emissions, improve air quality, and create a healthier and more comfortable teaching environment.

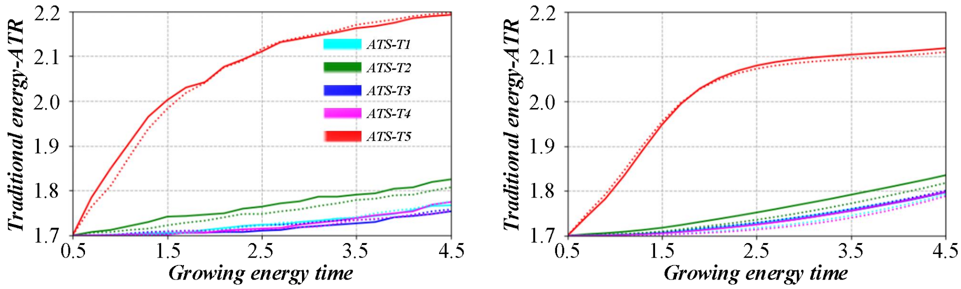

Figure 7. Fuel Cycle Crude Oil Consumption Chart

6. Conclusion

In the context of energy system optimization, smart energy transformation and system optimization and improvement provide essential support for the improvement of campus energy systems. The transformation of the campus teaching and learning environment is further facilitated through the continuous optimization and improvement of the campus energy system, which, to a certain extent, also improves the educational environment and the psychological health of teachers. In the process, the transformation and improvement of the smart energy system can lead to a significant improvement in the overall energy efficiency of the campus, which consumes only 63.6% of the traditional system in the raw material phase and the use phase. Despite the fact that in the energy production phase, the smart energy system's energy consumption is mainly powered by the grid, its overall combined efficiency is only 87.7% of the traditional energy production segment. The high energy conversion efficiency of the new system in the use phase makes the smart energy system 20.0% more energy efficient than the traditional system in terms of the overall energy cycle.

The energy savings created by the smart energy transformation on campus directly affect the overall environmental quality of the school and have a positive impact on the mental health of teachers. By reducing harmful emissions and improving air quality, teachers' working conditions in classrooms and office areas are significantly improved. This cleaner environment helps to reduce teachers' health problems caused by air pollution, such as respiratory illnesses, headaches, and fatigue. It reduces the physical, and therefore psychological, burden of their daily work. The optimization of smart energy systems not only offers advantages in terms of energy savings and reduced emissions but also positively affects teachers' professional satisfaction and psychological comfort. A more stable and environmentally friendly work environment helps to reduce teachers' anxiety in the face of unexpected events or changes in the environment. It enhances their emotional stability and psychological resilience. Teachers are able to focus more on teaching and student development without having to worry about threats to their health from the external environment. This sense of inner peace of mind and professional well-being is a key factor in improving teaching quality and promoting student development.

Project Funding

Research on the construction of social isolation risk prediction model for the frail elderly in community, 2024-ZZJH-279

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