Analysis and Prospect of Hybrid Wind-PV-ESS System under the Background of Carbon Peaking and Carbon Neutrality

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Abstract. With the large-scale use of fossil energy, the issue of rising temperatures caused by global warming is getting worse as time goes on, and various countries have successively launched the "carbon peaking and carbon neutrality goal" (double carbon goal). As a major country, China has a great challenge to achieve the double carbon goal, so the status of new energy is even more important. While wind energy and light energy occupy an important position in new energy sources, optimizing their utilization is a top priority. This paper includes the following sections: the fundamentals of wind power generating and some optimization of blade technology, the basic idea behind how photovoltaic cells produce electricity and the characteristics and comparison of several photovoltaic cells, a simple classification of MPPT technology, common energy storage technologies: flywheel, super capacitor, principle of hydrogen battery, Optimization of wind-solar storage combined debugging technology, etc.

Keywords: Double carbon goal, Hybrid Wind PV-ESS system, photovoltaic cells, MPPT technology.

1. Introduction

Since industrialization, humans have used a large amount of fossil fuels and at the same time emitted a large amount of greenhouse gases such as CO2, methane, and N2O, and the problem of global warming has become increasingly serious. For China, the total amount of CO2 emissions ranks first in the world, and the per capita emissions have exceeded the world average. At the 75th United Nations General Assembly, which took place on September 22, 2020, the Chinese President gravely revealed China's "double carbon objective." This aim states that China's CO2 emissions will strive to peak by 2030 and will strive to attain carbon neutrality by 2060.And among many countries that have set "double carbon goal" China has set a very short goal of completing within 30 years (79 years in the United Kingdom and 39 years in California in the United States) [1]. This is undoubtedly a challenge, so it is very necessary to study new energy such as clean energy to replace traditional fossil energy. In 2021, the Chinese President mentioned that: a "double carbon goal" "1+N" policy system has been established in China in order to support the realization of "double carbon goal." China will gradually release the industry carbon peaking implementation plan, and a number of supporting and safeguarding measures. China will continue to support the restructuring of the industrial and energy sectors, fiercely advance renewable energy, and quicken the design and construction of massive wind farms and solar base projects in the needed areas [2]. However, both wind energy and solar energy, which are widely used at present, have problems in their application. They are all unstable, that is, there is no wind anytime and anywhere, and the amount of wind energy in different regions varies greatly. The same is true for solar energy, which cannot make good use of solar energy at night and on cloudy days. In this case, the energy storage system becomes important. When there is no wind and light utilization, industrial machinery can also use the stored energy to continue to operate to achieve continuous work. Therefore, the Hybrid Wind PV-ESS system (HWPES) is very important.

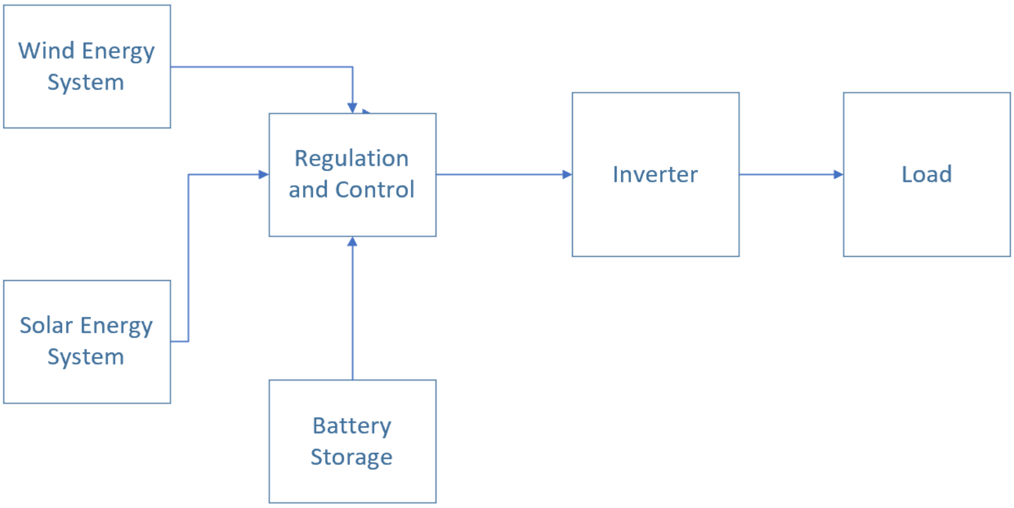

Figure 1. The HWPES Schematic diagram

The outline of the system is shown in figure 1, which is a schematic. The wind power storage system begins by utilizing the wind power generation system and the photovoltaic power generation system to convert wind energy and solar energy into electric energy and transport it to the controller. Next, a portion of the energy is stored in the battery so that it can be used even when there is neither wind nor light. This paper focuses primarily on the principle of wind power generation and the optimization of the corresponding technology, the principle of photovoltaic power generation, the characteristics, application and comparison of several types of photovoltaic cells, the basic classification of MPPT technology, the principle of common energy storage systems, and the optimization of Hybrid Wind PV-ESS System combined adjustment technology.

2. Wind power generation

2.1. The principle and development history of wind power generation

Wind energy is currently mainly used in the field of wind power generation. Figure 2 presents the diagrammatic representation of the schematic.

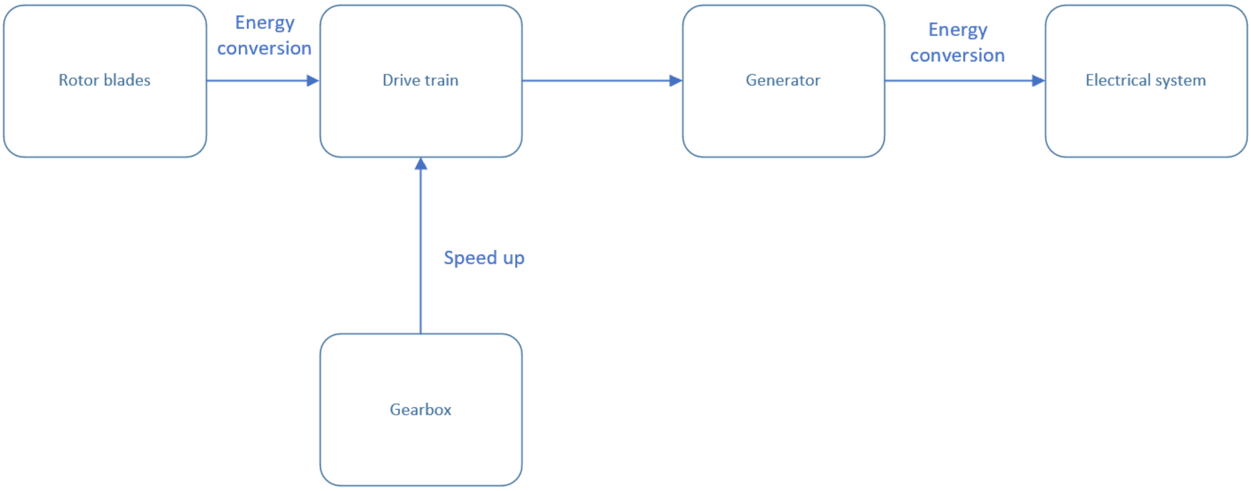

Figure 2. Schematic diagram of wind power generation

During operation, the rotor blades are turned by the wind, which converts the wind's energy into mechanical energy. The gearbox then speeds up the drive train, which transfers the mechanical energy to the generator. Finally, the generator converts the mechanical energy into electrical energy, which is then transported to the electrical system so it can be used. According to the Three Gorges Group, on the morning of December 29, 2021, the first batch of units of the Three Gorges Ulanqab New

Generation Grid Friendly Green Power Plant Demonstration Project invested by China Three Gorges New Energy Company, was successfully integrated into the Inner Mongolia power grid. The total construction scale of the project is 2 million kilowatts, and it is the largest Hybrid Wind PV-ESS System integrated project of energy storage configuration in China. With a total investment of 13.75 billion yuan, the first phase of the nation's first modern energy "fire, wind, wind, storage, production, research and development" integrated demonstration project was officially put into operation on August 31, 2022. The project integrates technology research and development innovation, energy supply guarantee, and optimization of power grid peak regulation. The combination of advantages such as capacity and power cost reduction have a good demonstration effect and great practical significance for promoting the high-quality development of the green energy-carrying industry.

2.2. Optimization of fan blade technology

2.2.1. Optimal design of spoiler

The spoiler of the blade actively changes the shape design of the fan blade, mainly to make up for the design defect caused by the small overall output of the blade root area. After the spoiler is installed, the flow velocity of the suction surface is greatly improved, the pressure on the suction surface decreases, and the flow rate on the pressure surface decreases, which leads to an increase in the pressure surface pressure, an increase in the pressure difference on the blade surface, an increase in the force on the blade surface, and an increase in work, the power increases. Literature [3] shows that due to the effect of pressure difference, the lift coefficient changes, and the lift coefficient and lift-drag ratio of the motor are increased. The increase of the lift coefficient caused by the spoiler is not divided into regions, that is, it causes the increase of the lift coefficient of all operating sections, which greatly increases the force on the local section, thereby increasing the power generation.

2.2.2. Optimum Design of Eddy Current Generator

The eddy current generator is a spoiler arranged vertically on the surface of the wind turbine blade at a fixed installation angle. By interacting with the incoming flow and using the wingtip vortices generated by it to realize the transition from the laminar boundary layer to the turbulent boundary layer, the purpose of increasing lift and reducing drag is achieved, and the lift-drag ratio and power generation efficiency are improved. The blade vortex generator mainly disturbs the fluid on one side of the suction surface. When the fluid separation occurs on the suction surface, the speed at the position of the suction surface is increased, the speed increases, the pressure on the suction surface decreases, and the pressure difference ΔP between the two sides increases. The force on the blade surface increases, resulting in an increase in the total amount of work and power. When the vortex generator is installed at the blade root with a large design angle of attack, strong wind gust or turbulence intensity, and there is dirt on the blade surface, its power-increasing advantage is more obvious. The vortex generators are small triangular fins of modified ASA material. The fins are arranged at a certain direction angle to each other. The length of the assembly is selected according to the amount of compensation for the actual output of the fan, which is generally 25% to 55% of the length of the blade. Install it on the inflow end of the blade near the root of the blade on the leeward side of the blade by connecting glue with imported anti-shedding foreign substances.

3. Photovoltaic power generation

3.1. Fundamentals of photovoltaic power generation

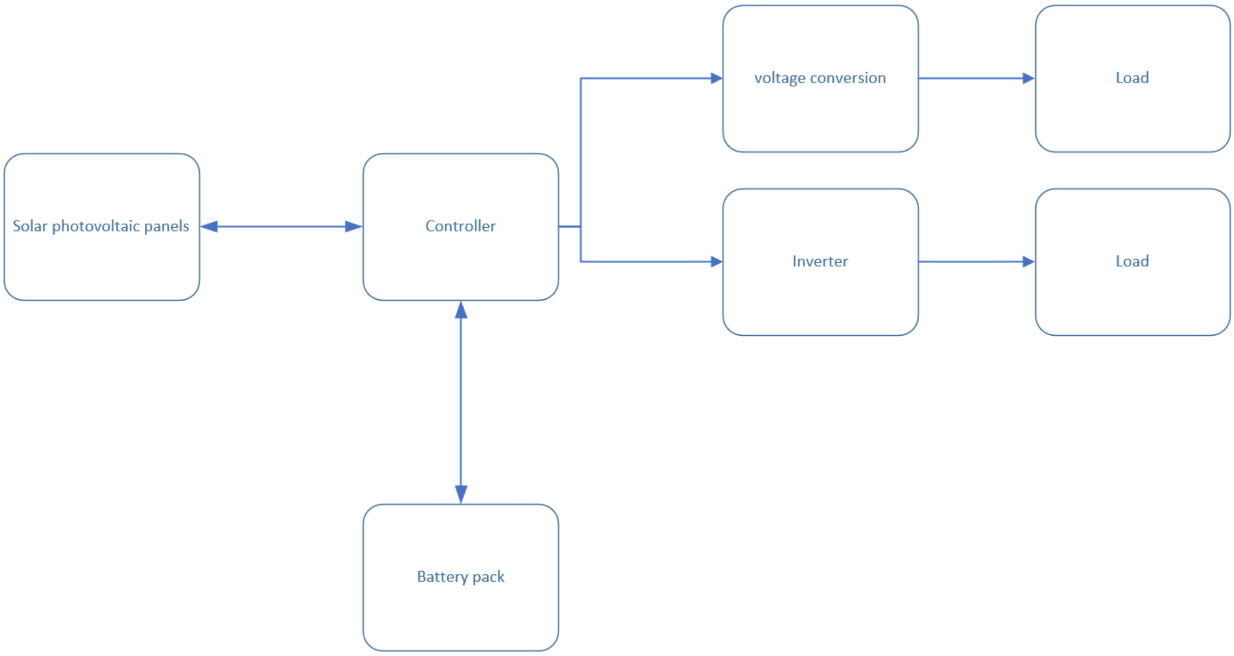

Figure 3. Photovoltaic power generation schematic

Figure 3 illustrates the fundamental idea behind how solar cells produce electricity. The photoelectric effect of semiconductors is the primary particular concept that underpins the generation of power using photovoltaics. The solar photovoltaic panels are exposed to light from the sun, which causes them to convert the light energy into electrical energy. The controller then makes adjustments to the amount of electrical energy that is stored in the battery pack. In the event that AC power is required, the inverter will change the DC power that is being outputted into AC power; alternatively, in the event that DC power is required, the voltage will be transformed to provide DC power as output.

The photovoltaic effect is used in the light-to-electricity straight conversion process to transform solar radiation energy directly into electrical energy. Batteries powered by photovoltaic cells are the key element in the process of transforming light into electricity. It is a kind of semiconductor photodiode. When the photodiode is exposed to sunlight, it will convert the light energy into electrical energy and generate electricity current. A solar cell array with a comparatively high output power may be created when numerous cells are joined in series or parallel. As a potential new energy source, solar cells have three benefits: permanence, cleanliness, and adaptability. What's more, it has a long lifespan and solar cells may be utilized for a very long period with just one investment as long as the sun is there. Solar cells will not pollute the environment in the same way as thermal or nuclear power plants will.

3.2. Characteristics and comparison of various types of photovoltaic cells

3.2.1. PV cells based on silicon

Depending on silicon materials, this kind of PV cells mainly include monocrystalline silicon photovoltaic cells (MSPC) and polycrystalline silicon photovoltaic cells (PSPC). The most efficient silicon for PV cells based on silicon is MS. According to reports, it's conversion efficiency in the lab has gotten as high as 26.7% [4]. However, due to the impact of material prices and cumbersome preparation processes, researchers have to find new low-cost photovoltaic cell materials to replace. As a result, polycrystalline silicon photovoltaic cells with dominant production cost quickly entered people's field of vision. The silicon atoms are organized into many crystal nuclei in the shape of diamond lattices when the liquid elemental silicon cools down and solidifies and then grow into polysilicon crystals. Polycrystalline silicon photovoltaic cells are made in a manner akin to that of monocrystalline silicon, but at a far cheaper cost. Until now, there are reports that the PSPC laboratory has the best conversion efficiency (22.8%) [5]. However, the conversion efficiency of PSPC that are actually used in the PV market is only about 18%, which is apparently lower than that of MSPC. This is because polycrystalline silicon is more difficult to crystallize than monocrystalline silicon, which has become a significant factor that has hampered the development of polycrystalline silicon photovoltaic cells.

3.2.2. Thin film PV cells (TFPC)

After PV cells based on silicon, TFPC represent a new generation of solar cells. TFPC consume less resources and, in theory, offer a greater conversion efficiency than silicon-based photovoltaic cells. Under the two carbon goal, the promotion of building integrated photovoltaic (BIPV) is an important measure, and TFPC are translucent and pliable, which can well meet the needs of photovoltaic buildings. Currently, cadmium telluride PV cells (CdTe), copper indium gallium selenide PV cells (CIGS), gallium arsenide PV cells (GaAs), etc. are the primary products of TFPC. The key benefits of CdTe thin film solar cells are steady performance, cheap production costs, and a greater large-scale operational efficiency compared with amorphous silicon photovoltaic cells, which has a very attractive development prospect [6]. And that’s the reason why this kind of PV cells have progressed quickly these years. However, Te is a scarce element, and there are only few natural reserves available for use in CdTe thin film PV cells. The primary direction of development is to decrease the consumption of Te element by thinning the film. Additionally, Cd is a hazardous element, thus appropriate recycling techniques are required to lessen environmental damage caused by batteries.

The reason why CIGS have entered people’s field of vision is that the toxicity issue that plagues CdTe cells is difficult to resolve, and the efficiency with which the cell converts light into electricity needs to be improved. The battery has many advantages. To begin, it is easy to install photovoltaic cells because of its low weight; second, it performs exceptionally well even in dim light, and the present efficiency in lab has reached 23.4% [7], which is likewise outstanding. However, CIGS batteries have also encountered obstacles in the process of industrialization, and the manufacturing process is relatively complex, resulting in high initial investment costs. However, CIGS cells are still the most important type of photovoltaic cells in my country’s photovoltaic industry. In order to enable CIGS batteries to contribute to carbon neutrality and realize industrialization, the current research direction is mainly to eliminate the influence of various losses of batteries on efficiency. Therefore, the future development trend of the battery is mainly: first, to replace the cadmium buffer layer of the battery. Since the current buffer layer of the CIGS battery is CdS, which is toxic, other materials need to be developed to replace CdS in the future; the second is to use a low-cost absorber layer; The third is to build a stacked battery system to form a multi-junction battery, which can theoretically greatly improve the efficiency of the battery; the fourth is to use a flexible substrate to lay the foundation for the promotion of photovoltaic building integration.

Finally, GaAs photovoltaic cells are currently the photovoltaic cells with the highest photoelectric conversion efficiency, and the efficiency of triple-junction GaAs thin film photovoltaic cells has reached 37.9% [8]. Except the great transform rate, the advantage of GaAs PV cells is that they have good high temperature resistance. Silicon cells basically cannot work above 200°C, but GaAs cells can work normally. However, its shortcomings are also obvious. In addition to the high cost, it also has poor mechanical properties and is difficult to process. At this stage, because the cost of GaAs cells is several times that of ordinary silicon-based photovoltaic cells, it is difficult to popularize and apply them in a large area. They are mainly used in space satellites, unmanned aerial vehicles and concept cars, and are still less in the field of civilian consumption. Compared with CIGS and CdTe thin film photovoltaic cells, GaAs photovoltaic cells have obvious advantages, namely higher efficiency and better stability, but their high cost makes them less competitive in the market, which is also an urgent need for this cell in the future. question. In order to promote the application of thin-film photovoltaic cells in the future, it is necessary to reduce the cost of the cells. For example, cheaper elements can be used to replace the more expensive elements in the original thin-film photovoltaic cells. For example, some scholars have replaced the expensive In and Ga in CIGS cells with Zn and Sn, thereby reducing the cost of the cell [7]. In addition, combined with the existing technology of silicon-based photovoltaic cells, the method of hybridization and doping elements can be used to ensure the performance of the battery, and at the same time, the preparation process of the battery can be simplified and the preparation cost of the battery can be reduced.

3.2.3. Some application defects of new photovoltaic cell

Silicon-based PV cells and TFPC materials provide challenging problems that are tough to tackle in the near future. Researchers try to find new materials to promote the industrialization process of photovoltaic cells, so new photovoltaic cells have entered the field of vision of researchers, The primary advantages of new photovoltaic cells are: thin film, high theoretical transform efficiency, extensive raw material availability, non-toxicity, currently the more popular new PV cells are: dye-sensitized PV cells and perovskite PV cells. Dye-sensitized solar cells (DSSCs) are actually a new type of photoelectrochemical cell developed by imitating the principle of photosynthesis. A new type of photovoltaic device developed [9]. Typical DSSCs are mainly composed of 5 main parts, which are conductive glass (coated with transparent conductive film), porous semiconductor film (nano-TiO2), dye sensitizer, electrolyte, and counter electrode. The current highest conversion efficiency of DSSCs is only 13% [10]. In addition, some researchers also coated ZnO nanoflowers with TiO2 on transparent electrodes to improve the conversion efficiency of cells [11]. In addition to the cost and the conversion efficiency, the stability of the PV cells is another factor that needs to be taken into consideration. At present, most DSSCs use liquid electrolytes to improve the battery efficiency. However, the liquid electrolyte has the defects of easy leakage and poor stability, which limit the industrial development of the battery.

In addition, there is a new type of photovoltaic cells, Perovskite solar cells (PSCs), which are currently a hot research topic in new photovoltaic cells. The efficiency of PSCs is higher than that of DSSCs, and the fabrication cost of PSCs is much lower than that of traditional silicon-based photovoltaic cells, which has an attractive development prospect [12]. In order to further improve the photoelectric conversion efficiency of perovskite cells, the researchers also conduct further research on the thin film preparation process of the cell, the design of the carrier transport interface layer, the selection of doping materials, and the design of the cell device structure. After continuous development, experts successfully increase the maximum efficiency of PSCs batteries to 26.7% in 2020 [13]. At present, the biggest disadvantage of perovskite cells is that the materials are unstable, and the organic cations in perovskite cells are volatile, which leads to the decomposition of perovskite cells. Therefore, two-dimensional halide perovskites with ultra-high humidity stability have attracted the attention of researchers from all over the world [14]. Two-dimensional perovskite cells are a very promising form of perovskite cells, and their unique tunability can be used to solve the problems of light stability and water-oxygen stability of a series of perovskite cells. In addition, Liu Haichao et al. [15] applied biomass porous carbon materials to perovskite cells to improve battery efficiency. This work can not only reduce the preparation cost of biomass carbon materials, but also accelerate the commercialization process of PSCs.

3.2.4. Comparison of various photovoltaic cells

Table 1 shows the difference between various photovoltaic cells, includes: types, conversion efficiency, advantage, disadvantage and application field.

Table 1. Comparison of various photovoltaic cells

Types of photovoltaic cells	Conversion efficiency	advantage	disadvantage	Application field
Monocrystalline silicon photovoltaic cells	26.7%	Highest efficiency among silicon-based photovoltaics	complicated preparation process; high cost	Photovoltaic power station
Polycrystalline silicon photovoltaic cells	22.8%	Lower cost than monocrystalline silicon cells	low efficiency	Photovoltaic power station
CdTe	22.1%	Stable performance, low manufacturing cost higher large-scale operating efficiency	Toxic, the conversion efficiency is not high enough, the required element (Te) reserves are insufficient	PV building integration
CIGS	23.4%	Lightweight, excellent low-light performance, can be made into various colors, high photoelectric conversion efficiency	The complex manufacturing process leads to high initial investment costs, the key material in element is scarce	PV building integration
GaAs	37.9%	High photoelectric conversion efficiency good high- temperature resistance	High cost, poor mechanical properties, difficult to process	space satellites, unmanned aerial vehicles, concept cars
DSSCs	13%	Long battery life simple structure	The conversion efficiency is low, the cost is high, and the battery is not stable enough	Still in the laboratory stage
PSCs	26.7%	Low cost high efficiency	Short life	PV building integration

3.3. MPPT technology

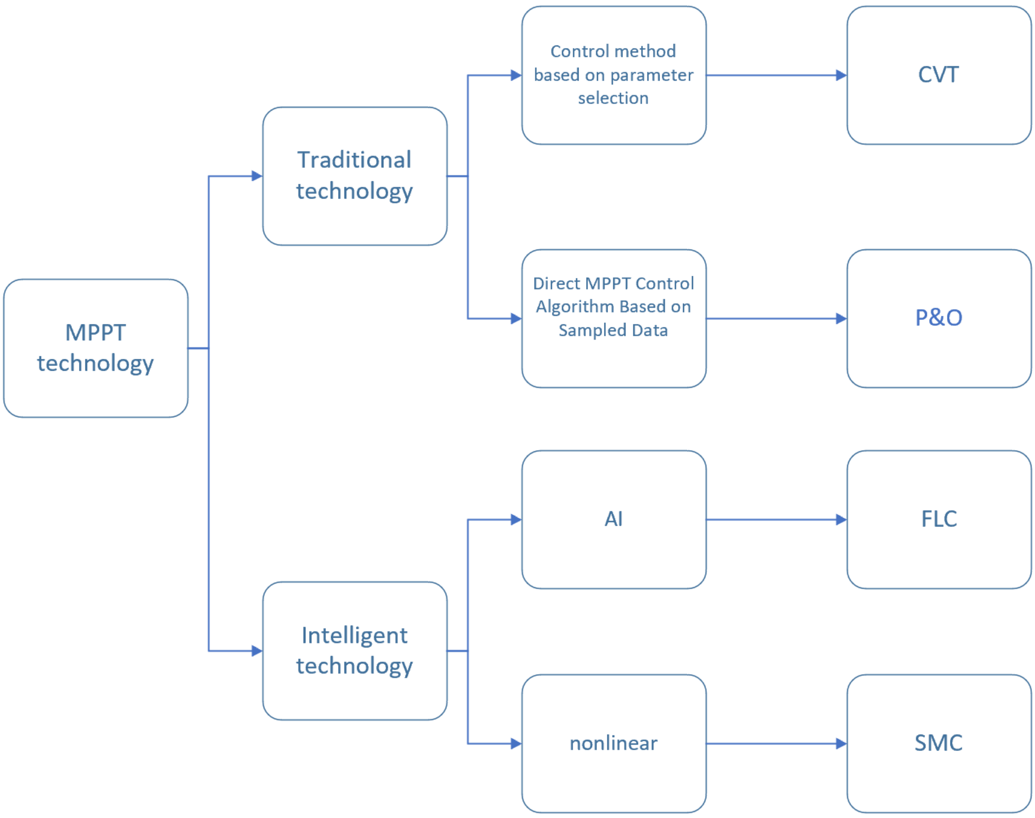

Figure 4. Simple classification of MPPT technology schematic

Figure 4 roughly divides MPPT (maximum power point tracking) technology into two categories: traditional and intelligent, and an example of a control method will be introduced in each sub-category.

3.3.1. Traditional technology - parameter selection

Algorithm for controlling depending on parameter selection utilize the knowledge of PV panel's defined parameters to track control of the MPP and measure operational conditions' parameters. The intrinsic physical parameters of photovoltaic panels, radiation and operating temperature are measured to create an improved mathematical model. These models can predict the panel's typical curves of P-V and I-V for a given operating condition, thereby determining the MPP. Researchers usually use a model which shows equivalent circuit of photovoltaic cells, and for the performance of the method, the precision of a number of parameters in this model is crucial. Such control methods mainly include CVT and so on. CVT [16] is predicated on the hypothesis that the voltage of the module measured at the MPP and the voltage measured across the open circuit have a linear relationship, making it the most basic technique of parameter selection for MPPT. Using this approach, the module terminal voltage is modified in accordance with the open circuit value. However, this method is not able to perfectly achieve MPPT, especially when there is large temperature varies.

3.3.2. Traditional technology - Direct control method based on sampled data

This kind of technique collects sampled data from the PV array, such as current, power, and voltage, to track the MPP. These direct techniques are simple to use in practice and do not rely on any PV model, so they are widely used. Techniques include P&O and others, and these techniques often improve tracking accuracy and speed by combining with intelligent search algorithms. P&O [17] is also recognized as hill climbing. It is one of the methods used the most frequently to deploy MPPT in PV systems. P&O is dependable, straightforward and simple to use. However, the P&O algorithm tracks the MPP by continuously changing the PV array's terminal voltage, which is likely to cause oscillations in the output power. In addition, this approach can lead to power losses in the photovoltaic system as environmental conditions change. A PV module's P-V characteristic curve is nonlinear and changes in response to radiation and temperature, and may have peaks more than one, so traditional MPPT control methods may cannot work. To solve this problem, Numerous intelligent algorithm-based MPPT control approaches, including as FLC and SMC, have been presented and effectively used.

3.2.3. Intelligent technology -AI

A popular AI algorithm built on a collection of fuzzy rules is FLC [18]. Fuzzification, control rule assessment, and de-fuzzification are the three stages of its implementation. The primary characteristic of this technique is the integration of expertise and competence of its users with the linguistic regulations that are used to manage the system. Additionally, this approaches can hunt down the MPP in a very short time, and there is no further variation once the MPP is attained under steady-state circumstances, which means it owns better nature no matter in differing degrees of motion and stillness. However, the primary shortage of this method is that the problem of drift will appear when irradiance change and, in that case, it is complicated to implement. To increase convergence rate, reduce steady-state fluctuation, and simplify implementation, several researchers tried combining the conventional MPPT algorithm with FLC.

3.2.4. Intelligent technology-discontinuity

The discontinuity of control is used in SMC [19], which relies on the fast shifting to coerce the closed-loop mechanism to arrive to and stay on the intended surface which is smooth enough to slide on. The speed of photovoltaic system tracking can be significantly increased with this technique, however the properties of both dynamic motion and stable conditions will depend on the switching device's choice of modulation depth step size. As the ΔU rises, the tracking velocity may be increased, but the PV array's output power and voltage fluctuation will also grow at the same time.

4. Energy storage technology

4.1. Types of energy storage technologies that are commonly used and the features of each

4.1.1. Flywheel energy storage technology (FES)

Figure 5 illustrates how the flywheel system works as an energy storage device. When the mechanism needs to store excess electrical energy, the external electrical energy is input into the motor to drive it to drive the flywheel to rotate, thereby converting the electrical energy into flywheel kinetic energy for storage; and when the outside world needs electricity, the high-speed rotating flywheel drives the generator to generate electricity. The kinetic energy is converted into electrical energy, and then the various voltages and frequencies of the external electrical energy are met through the converter.

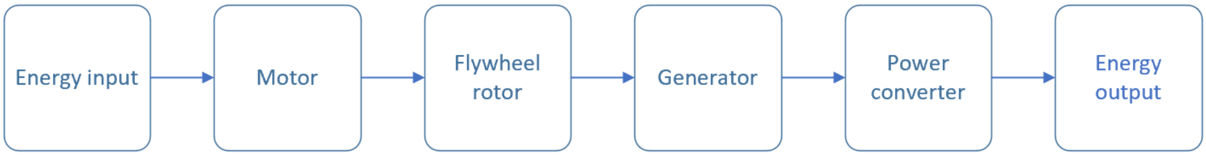

Figure 5. Schematic diagram of FES

During the traditional FES period, a large amount of loss will be generated. In order to solve the problem of wear and tear, superconducting magnetic levitation technology is gradually applied to the FES device, with the help of new composite materials to enhance the energy storage (ES) density and reduce the size of the ES device. The energy conversion rate of FES is about 90%, and there is still room for improvement. It has the advantages of no pollution, convenient maintenance, and unlimited charge and discharge. The FES technology has seen significant advancements thanks to the growth of the power production industry as a whole as well as the power system. The FES is used to compensate for short-term changes in power generation and maintain the stability of the power system. At the same time, the modular combined FES method is proposed. The charging and discharging efficiency of the FES is greatly improved. In the situation of large-scale grid connection, in order to maintain and highlight the advantages of FES, the research goal of FES is gradually focused on the research of grid-connected FES system, and new micro-loss bearings and high-strength flywheel materials are introduced to improve the FES. The performance of the ES system makes theFES system tend to develop with high speed, large capacity and modularization.

4.1.2. Supercapacitor energy storage

Diagrammatic representation of the supercapacitor ES technology can be shown in Figure 6.

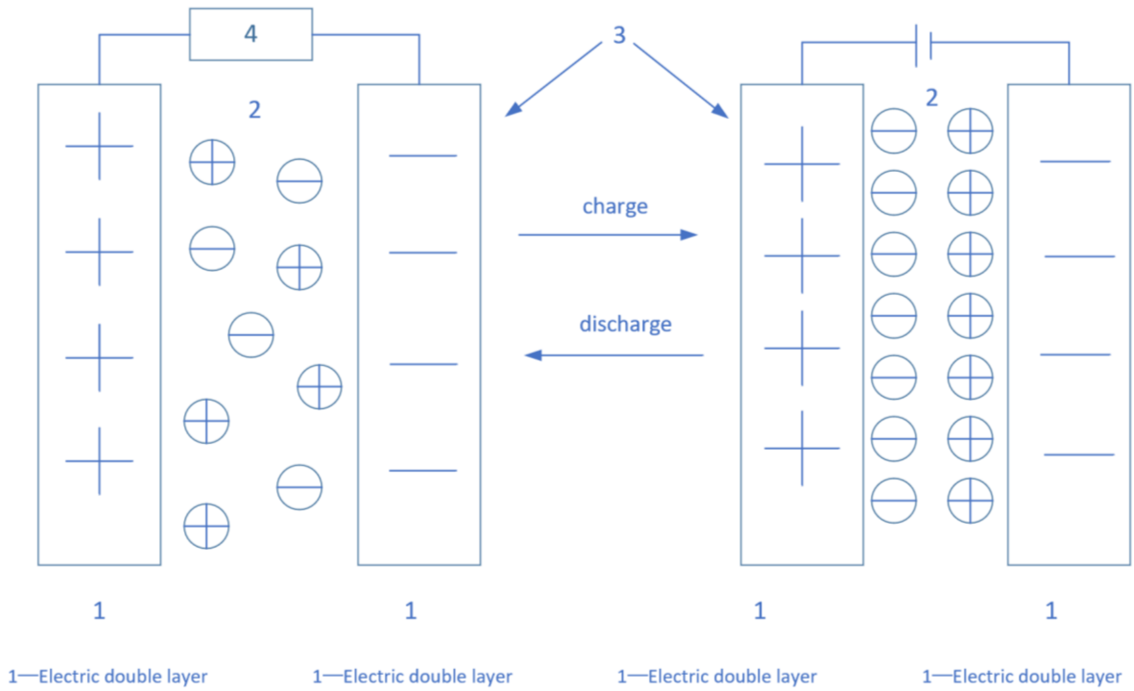

Figure 6. Schematic diagram of Supercapacitor ES

Due to the action of the external electric field, the space charge on the electrode plate will attract the ions in the electrolyte during charging, so that an ionic layer is formed at a certain distance from the surface of the electrode plate, and an electric double layer structure is formed with the remaining charges on the surface of the electrode plate. The charge is the same, the charge is opposite. And due to the existence of the potential barrier, the charge will not be neutralized. The same goes for the other plate. After charging is completed and the applied electric field is withdrawn, the anions and cations in the electrolyte and the positive and negative charges on the plate attract each other, and the electric double layer will not disappear, so the energy is stored in the electric double layer. When the load is connected, due to the potential difference between the positive and negative electrodes, a current will be generated, and the charge will flow from the positive electrode to the negative electrode through the load. At the same time, the attracted anions and cations in the electric double layer are freed from the shackles of the Coulomb force and dispersed in the electrolyte, the electric double layer disappears, and the energy is released [20].

The device structure of the supercapacitor energy storage technology is relatively simple, and no toxic substances are produced, and the environmental protection is guaranteed. In addition, the current generated by the supercapacitor energy storage method is relatively large, and the charging time is relatively short, which can maintain the above-mentioned during the charging and discharging cycle. However, supercapacitor energy storage also has certain disadvantages. Supercapacitor energy storage has high requirements on the voltage during charging, and a single capacitor voltage cannot meet the needs of efficient charging.

4.1.3. Application of hydrogen energy storage system

Hydrogen fuel energy storage is mainly realized by electrochemical devices, which convert the chemical energy in oxidants and fuels into electrical energy. Under the guidance of the "two-carbon" strategic goal and sustainable development strategy, hydrogen fuel energy storage technology is gradually applied to power generation systems. middle. In the wind power generation system, the proton exchange membrane fuel energy storage method is the most widely used. During the operation of the proton exchange membrane fuel energy storage device, the fuel gas and oxygen enter the two poles through the double-click plate gas channel, and then enter the catalytic layer after passing through the diffusion area of the membrane electrode. At this time, the hydrogen will be decomposed into water, Protons and electrons, water and protons enter the cathode through the sulfonic acid group of the proton exchange membrane, and electrons enter the cathode through the external circuit. Finally, under the action of the cathode catalyst, electrons, protons and water react with oxygen molecules, in a series of chemical reactions. During the reaction, the electric energy storage and charging and discharging process are completed, and the long-term energy storage is realized under the application of compression, liquefaction and metallization energy storage, and the effect is remarkable [21]. In the wind power generation system, the hydrogen energy storage device is composed of a hydrogen storage tank, an electrolyzer, and a fuel energy storage device. When the wind energy is sufficient, the electrolyzer generates hydrogen by electrolyzing water, which will be stored in the hydrogen storage tank. The excess power at this time will be transferred out to become the load. When the wind power generation deficit occurs, the hydrogen energy storage device will carry out the reaction of oxygen and hydrogen, and then generate electric energy to make up for the system load and maintain the stability of the power system. At this stage, the technical research on hydrogen fuel energy storage is gradually deepening, and technical difficulties are gradually overcome. Fuel cells can directly convert the chemical energy of hydrogen into electrical energy, which is one of the mainstream technologies for hydrogen energy utilization.

Table 2. Comparison of various types of batteries

Battery Type	operating temperature	Regular capacity/kw	efficiency/%	Application scenarios	advantage	disadvantage
PEMFC	50~100	<1~100	35~60	Backup power, mobile power and transportation	Low temperature operation, quick start	Catalysts are expensive and sensitive to fuel impurities
AFC	90~100	10~100	60	air defense	High conversion rate, low price	Sensitive to fuel impurities (especially CO2), electrolyte maintenance is difficult
PAFC	150~200	400	40	Distributed Generation	Relatively low fuel quality requirements	Using platinum catalyst, lengthy startup period and low single fuel cell power
MCFC	600~700	300~3000	45~50	Distributed Generation	High efficiency, different catalysts can be used	Easy to corrode in high temperature condition, lengthy startup period, low energy density
SOFC	700~1000	1~2000	60	Generation	High efficiency, Different catalysts, solid electrolytes, can all be employed, relatively minimal fuel purity requirements	Easy to corrode at high temperature, lengthy startup period

According to different working temperatures and different electrolyte materials, hydrogen fuel cells can be divided into proton exchange membrane fuel cells (PEMFC), alkaline fuel cells (AFC) and phosphoric acid fuel cells under medium and low temperature conditions. acid fuel cell, PAFC). In addition, there are molten carbonate fuel cells (MCFC) and solid oxide fuel cells (SOFC) that work under high temperature conditions. Table 2 lists the main fuel cell characteristics and application scenarios [22].

5. Hybrid wind PV-ESS system optimization technology

The Table 3 shows different aim of optimization technology of hybrid wind PV-ESS system.

Table 3. Comparison of optimization technology of hybrid wind PV-ESS system

Optimization technology	Aim
Genetic algorithm	reduce annual energy waste
MATTDA technology	good autonomy, coordination, adaptability and sociality
Microgrid technology	economical and efficient

5.1. Genetic algorithm

Professor Holland is the first people who proposed Genetic algorithm, the first intelligent evolutionary algorithm in 1971 [23]. In order to choose the best solution to problem, he used a fitness function. Problem solutions which have higher fitness values have high chances of being passed on to the next generation. Deterministic planning with a single scenario is therefore inappropriate for planning a wind turbine integrated power system. Because of the unpredictable feature of the need and power supply, a technique to combine renewable DG dispatchable and non-dispatchable units is proposed to reduce annual energy waste. Genetic algorithm optimization takes into consideration the unpredictable characteristic of wind and loads in this studied system. The vast majority of studies that have been conducted on wind farm integrated systems functioning with a power factor of one to supply the grid with active electricity so that it may be easily analysed.

5.2. MATTDA technology

An optimization method based on MATTDA (multi- agent technology for two-dimensional alliance) technology is proposed in the literature [24]. The technology has good autonomy, coordination, adaptability and sociality, and can well solve the coordination and optimization problem of wide-area distributed systems. However, few studies have introduced MATTDA into the wide-area coordination optimization of wind-solar-storage systems. The current research mainly focuses on the optimal control and reliability evaluation of wind-solar-storage combined power generation systems. The architecture given in the literature is based on MATTDA to realize the layered and partitioned autonomous control of distributed wind and solar storage systems, which can be integrated and deployed in distributed power generation systems including renewable energy in the future to achieve coordinated optimal control of a large number of distributed power sources.

5.3. Microgrid technology

An optimization method based on microgrid technology is proposed in the literature [25]. Microgrid technology is one of the effective ways to efficiently utilize renewable energy and solve the grid connection problem of distributed power generation systems. The wind-solar-storage hybrid power generation system utilizes the complementary characteristics of wind energy and solar energy, which can reduce the capacity of the energy storage device and make the operation more stable. At present, many studies on microgrids are based on wind-solar-storage complementary microgrid systems. The operating cost of microgrids is generally high and the economy is poor, which restricts the promotion and application of microgrids. Therefore, optimizing the microgrid technology can optimize the wind-solar storage system economically and efficiently.

6. Conclusion

In general, the primary purpose of this paper is to introduce the principle of wind power generation, the technical optimization method of wind turbine blades, the characteristics and comparison of various photovoltaic cells, the basic classification of MPPT technology, characteristics of the common energy storage technology -FES, super capacitors, hydrogen energy storage. And the optimization of Hybrid Wind PV-ESS System combined technology. For Hybrid Wind PV-ESS System, more intelligent algorithms can be added in the future, combined with the background of the current era, considering carbon emissions and other issues, to establish a more comprehensive Hybrid Wind PV-ESS System adjustment plan.

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