Research on Integrated Energy Technology of Green Campus Combined with Wind, Solar, Storage, Charging, Industry, Academia and Research

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Abstract. The research on the integration of wind, solar, storage, charging, industry, academia and research is an important embodiment of promoting the traditional energy system to step forward into the energy Internet system. The green smart campus is also a typical demonstration of the energy Internet. In this paper, an integrated construction scheme of wind, solar, storage, charging, industry, academia and research is put forward in combination with the actual situation. In order to realize multi-energy complementarity in a more scientific way, the operation mode of the micro-grid system is studied and analyzed in depth under grid-connected and off-grid modes, so that the emergency power for critical loads can be guaranteed when power is lost. The scheme provides a set of new and concrete solutions for colleges and universities to realize green and smart campus.

Keywords. Multi-energy complementarity; energy internet; micro-grid system; integration.

1. Introduction
With the rapid development of the economy, China’s resources, the environment and other issues are gradually emerging [1]. In order to achieve sustainable green and economic development, we must implement energy conservation and emission reduction strategies. Green and pollution-free clean energy is the key to energy conservation and emission reduction strategies. In response to various problems that may be encountered in energy production, transmission, consumption, etc., state grid co., ltd. takes the lead in putting forward new concepts such as strong smart power grid, ubiquitous power Internet of things, and energy ecosystem, etc. Projects such as the construction of distributed energy, energy storage and microgrid have been carried out rapidly. With the continuous expansion of the scale of running schools, the construction area of colleges and universities has been expanding, and the energy consumption of buildings has increased dramatically. The university has become an important energy consumer. Therefore, it is very important to promote energy conservation and emission reduction in colleges and universities. It is extremely urgent to build a green and conservation-oriented campus [2].

The main energy consumption of colleges discussed in this paper mainly comes from the energy used in teaching, training, office and training sites. Establishing an energy supply system of multi-energy complementary and efficient in transmission and utilization has become one of the key tasks for universities to respond to national energy conservation and emission reduction policies. On the one hand, it has responded positively to the national energy development strategy and comprehensive energy utilization policy. With the help of advanced smart technology, it has greatly expanded the way
to achieve interaction with the grid’s supply and demand and broaden the interaction’s scale friendly. By taking advantage of renewable energy (wind power, solar power), increasing the proportion of new energy generation and reducing non-renewable fuel consumption, we can make more rational use of existing resources, reduce electricity costs and the investment demand for distribution network equipment, which plays an active role in the production and living of electricity on campus. On the other hand, the integration of production, academia and research has taken a step forward for the landing of corporate universities. Through the construction of the project, it can provide a high level of skilled talents for the social and power industry. Therefore, it is imperative to study and land the integrated energy technology of green campus that combined with wind, solar, storage, charging, industry, academia and research.

At present, most of the research on wind and solar, storage is still on the paper and simulation stage. These studies do not give specific construction implementation plans under the actual site conditions and matching degree. In Ref. [3], the author simulated the energy allocation strategy of wind solar energy and storage, but due to the lack of actual application environment, the energy distribution strategy has major defects. In Ref. [4], the energy optimization strategy considering the wind and solar storage access family is studied, but the simplified processing is adopted in the algorithm and model, and the research is not based on a large amount of actual data. Ref. [5] only considers the DC power supply for the access of the new energy electric vehicle to the microgrid, and does not consider how to deal with the AC power supply. Ref. [6] explained the control of wind-solar complementary microgrid switching in island mode, a non-energy storage microgrid scheduling optimization algorithm based on diesel generator control is proposed, which does not consider how the microgrid switching will be controlled after integration. In this paper, the research on the comprehensive energy technology of the green is a concrete construction plan based on site survey and based on a large amount of data, which is currently under active construction. Although there are many individual studies on wind, solar and storage, there is little research on integration of wind, solar, storage, charging, industry, academia and research. The load of this study includes both AC charging pile and DC charging pile, and is discussed in the grid-connected and off-grid operation control modes. The concept of “Integration of Industry, Education and Research” is an important measure to consider the high-quality comprehensive energy service talents for the future of our school. In the aspect of “learning”, we can cultivate a group of high-quality skilled talents who can design, calculate capacity, install and operate, so that students can get employment upon graduation. In terms of “research”, we can study the power generation characteristics of various types of photovoltaic panels under various meteorological conditions, study resource scheduling strategies, etc., and integrate scientific and educational innovation into the project. Therefore, the research and landing of the project has a strong promotion and demonstration effect.

2. Research and Analysis of Intelligent Microgrid System

2.1. Overall Architecture of Intelligent Micro-grid System

The microgrid system consists of three parts: distributed power supply, power load and microgrid control system [7]. Distributed PV and distributed wind turbines form the power generation unit of the microgrid system. Electrical load includes 4 branches: important load of building 12, central machine room of building 2, central machine room of building 9 and outdoor lighting. The micro-grid control system can manage all the distributed power supply and load uniformly, solve the problem of distributed power supply output fluctuation, greatly improve the effective running time and utilization efficiency of distributed power supply, at the same time, reduce the energy cost of the school, and strengthen the power safety of the park.

Through intelligent optimal configuration and management technology, this scheme adopts advanced micro-grid technology to provide intelligent and diversified electricity services, and builds a 250 kW/172.8 kWh wind and solar, storage micro-grid power generation system. The ac bus voltage is 400 V, and 10 kV grid connection is made after box transformation. The overall architecture topology is shown in figure 1. The distributed power supply gives priority to the load, and the
remaining electricity is charged to the energy storage system. If the distributed power supply output still has surplus, the surplus will go online. The main equipment includes: photovoltaic modules, photovoltaic supports, grid-connected systems, wind turbines, fan controllers/inverters, two-way energy storage inverters, lithium iron phosphate battery packs, BMS battery management systems, intelligent power distribution cabinets, micro Grid energy control system and data monitoring system.

Figure 1. Overall architecture topology diagram.

2.2. Microgrid System Operation Scheme
The microgrid can use the intelligent control of the energy storage system to cut the peaks and fill the valley. In the peak period of power consumption, the standby capacity of the large power grid is reduced; in the case of grid failure, the microgrid off-grid operation can ensure the reliability of power supply and accelerate the fault recovery of the large power grid [8].

When the microgrid is operating in the grid-connected mode, if the power generation unit generates more power than the micro-grid, the excess power is stored in the energy-storage battery. If the power generation unit generates less power, part of the energy of the energy storage unit is released. When the microgrid is operated in the island mode, the real-time balance of the load between the distributed generation system and the microgrid can be realized by intelligently controlling the charge and discharge of the energy storage system [9], thereby ensuring stable island operation of the microgrid.

In this solution, the wind and solar-storage micro network system can seamlessly switch its working mode between grid-connected and off-grid.

2.2.1. Grid-connected Mode. PV and fan energy is sufficient: PV and fan are preferentially supplied to the load of 2#, 9#, 12# building room, and the remaining energy is used to charge the battery pack.

Insufficient energy of PV and fan: When the SOC of the battery pack is greater than or equal to the set value A, the PV/fan and the battery pack simultaneously supply power to the 2#, 9#, 12# floor room and the outdoor lighting load. When the SOC of the battery pack is less than the set value A, the PV/fan and the power grid supply power to the 2#, 9#, and 12# building rooms, and the grid charge the battery pack at the same time.

No PV and fan energy: When the SOC of the battery pack is greater than or equal to the set value A, the battery pack supplies power to the 2#, 9#, 12# floor room and the outdoor lighting load; When the SOC of the battery pack is less than the set value A, the grid supplies power to the 2#, 9#, 12# floor room and outdoor lighting loads, and charge the battery pack at the same time.
2.2.2. Off-grid Mode. PV and fan energy is sufficient: PV and fan are preferentially supplied to the load of 2#, 9#, 12# building room. If there is still surplus, the micro-grid energy control system will limit the power output of photovoltaic and fan.

Insufficient energy of PV and fan: When the SOC of the battery pack is greater than or equal to the set value A, the PV/fan and the battery pack simultaneously supply power to the 2#, 9#, 12# floor room and the outdoor lighting load. When the SOC of the battery pack is less than the set value A, the system limits the use of controllable load, and reserves the power supply of important load room in building 2, 9 and 12. When the battery SOC is equal to the set value B, the system will stop the power supply, and the normal power supply will be restored when the battery level returns to the set value.

No PV and fan energy: When the SOC of the battery pack is greater than or equal to the set value A, the battery pack supplies power to the 2#, 9#, 12# floor room and the outdoor lighting load; When the SOC of the battery pack is less than the set value A, the system limits the use of controllable load, and reserves the power supply of important load room in building 2, 9 and 12. When the battery SOC is equal to the set value B, the system will stop the power supply, and the normal power supply will be restored when the battery level returns to the set value.

3. Construction Implementation Plan and Income Analysis

The construction implementation plan of this paper mainly includes four parts: wind power generation, photovoltaic power generation, energy storage system and charging pile. The specific construction implementation plan is shown in figure 2.

Figure 2. Construction plan.

3.1. New Energy Photovoltaic Demonstration Carport

According to the current production capacity of mainstream photovoltaic module manufacturers in China, and under the condition that the photovoltaic industry in China starts construction, construction and grid connection in the same period, this program will adopt a variety of solar modules, such as monocrystalline silicon and polycrystalline silicon, so as to pay equal attention to both teaching and demonstration functions.

According to the site survey, the available area is 983.37 m², and the installed capacity is 168.8 KW. There are 2 types of components, totalling 480 pieces. Among them, 320 pieces of double-glass single crystal components (365 Wp) and 160 pieces of double-glass polycrystalline components (325 Wp). The PV system is interconnected with the 250 KW microgrid system through the inverter, and the output voltage level is 400 V. The specific installation conditions are shown in table 1.
Table 1. Formatting sections, subsections and subsubsections.

| Install position | Monolithic power (Wp) | Number of installations | Proposed installed capacity (kWp) | Inverter configuration |
|------------------|-----------------------|-------------------------|-----------------------------------|------------------------|
| No. 1 carpot     | 365                   | 160                     | 58.4                              | 60 kW                  |
| No. 2 corpot     | 325                   | 160                     | 52                                | 50 kW                  |

The annual average peak sunshine hours in Changsha is 3.29 hours. According to the installed capacity of 168.8 kWp, the first year is reduced by 2.5%, and the subsequent annual decline is not more than 0.7%. The 25-year power generation of this program is shown in table 2. Assuming that the user’s electricity price is 0.58 Yuan/kWh and Changsha City subsidies 0.1 Yuan/kWh (continuous subsidy for 5 years), the average annual income is about 110,200 Yuan, and the accumulated 25 years is about 2,227,300 Yuan.

Table 2. 25-year power generation of photovoltaic carports.

| Calculation of power generation of photovoltaic power station for 25 years | Power attenuation/annual | 0.73% |
|-----------------------------|--------------------------|-------|
| Years | Attenuation rate | Annual electricity generation (10,000 kWh) | Years | Attenuation rate | Annual electricity generation (10,000 kWh) |
| 1 | 2.50% | 16.21 | 14 | 11.98% | 14.69 |
| 2 | 3.23% | 16.09 | 15 | 12.71% | 14.58 |
| 3 | 3.96% | 15.97 | 16 | 13.44% | 14.46 |
| 4 | 4.69% | 15.86 | 17 | 14.16% | 14.34 |
| 5 | 5.42% | 15.74 | 18 | 14.89% | 14.23 |
| 6 | 6.15% | 15.62 | 19 | 15.62% | 14.11 |
| 7 | 6.87% | 15.51 | 20 | 16.35% | 14.00 |
| 8 | 7.60% | 15.39 | 21 | 17.08% | 13.88 |
| 9 | 8.33% | 15.28 | 22 | 17.81% | 13.76 |
| 10 | 9.06% | 15.16 | 23 | 18.54% | 13.65 |
| 11 | 9.79% | 15.04 | 24 | 19.27% | 13.53 |
| 12 | 10.52% | 14.93 | 25 | 20.00% | 13.41 |
| 13 | 11.25% | 14.81 | | | |
| Cumulative power generation in 25 years (10,000 kWh) | 370.248 |
| Annual average power generation in 25 years (10,000 kWh) | 14.810 |
| Annual average power generation per watt (kWh) | 7 |

3.2. Wind Power System
The average wind speed in Changsha is 2.5 m/s. According to the distribution of wind energy in the school site, the safe distance, and the demand for teaching demonstration, the wind resource on the east side of the parking lot is the best. The wind speed can meet the project demand and can be used as the installation site for the unit. The wind power generation system includes a 5 KW horizontal axis wind power generation unit and two 600 W vertical axis wind power generation units, which are connected with the micro-grid system after rectification and inverter, and output voltage level is 400 V.
3.3. Energy Storage Systemind Power System
As a demonstration project of the school, this project has high requirements for the safety and stability of the battery, and the selected battery products must also take into consideration the advantages of green environmental protection, advanced technology and long battery life. At present, the more commonly used batteries on the market mainly include ternary lithium batteries, lithium iron phosphate batteries, lead-acid batteries, etc., because the energy management system cannot distinguish a variety of battery types (charging current, discharge current, etc. cannot be multi-identified). In comparison, the lithium iron phosphate battery technology is mature, the safety and stability is good, the cycle life is long, and the number of full discharges can reach 4,000 times. The first phase demonstration project of the Changsha battery energy storage power station built in Hunan Province also uses this type of battery. The energy management system completes the collection of battery information and the monitoring of data in the system, and the intelligent control of equipment such as inverters, so as to realize the intelligent management of energy storage system charge and discharge.

According to the demand of the college’s primary load, the energy storage is considered to supply power to the central computer room of Buildings 2, 9, and 12, as well as for outdoor lighting. The total load capacity is about 150 kW. The energy storage system adopts a new lithium iron phosphate battery pack with a capacity of 250 kW/172.8 kWh. The normal cycle power supply time of the energy storage battery is 0.5 hours, the coefficient is about 0.5, and the full discharge state can guarantee the power supply for 1 hour.

3.4. Charging Pile System
With the adjustment of national energy structure, new energy vehicles will be the trend of future development. With the development of the industry, there are more and more new energy vehicles, and the demand for new energy charging piles is also increasing. This project not only meets the demand of teaching demonstration, but also meets the charging demand of new energy vehicles of school staff. In the parking lot, this project will construct 3 double-gun dc quick charging piles (60 kW) and 12 single-gun ac slow charging piles (7 kW), supporting 10 kV 315 kVA box transformer. According to the actual use of the site, the new energy photovoltaic demonstration shed chooses floor type, dc quick charging pile and floor type, ac slow charging pile.

According to the standards set by the National Development and Reform Commission, the charging fee for electric vehicles is capped at 15% of the price of gasoline on the day of the 92nd. It is now uniformly charged according to the standard of 1.134 yuan/kWh, which is used as the operating income of the charging pile, as shown in table 3.

| Charging pile capacity (kW) | Number of piles | Single pile service charge (Yuan/kWh) | Rechargeable per hour (output 70%) | Daily charging time of single pile (Hours) | Total daily income (Yuan) | Total annual income (Yuan) |
|-----------------------------|----------------|--------------------------------------|-------------------------------------|------------------------------------------|--------------------------|--------------------------|
| 264                         | 15             | 1.134                                | 184.8                               | 2                                        | 419.1                    | 152981.14                |

Remarks: Charging time is calculated as 2 hours per pile.

4. Conclusion
The comprehensive energy technology solutions for wind, solar, storage, charging, industry, academia and research proposed in this paper are concrete and feasible, not a separate study or simulation, and can provide specific implementation scheme for colleges to build green smart campus, whose promotion has a typical demonstration effect. At the same time, this scheme uses renewable clean energy as the source end to generate electricity, and is equipped with energy storage system for the stable operation of the power grid system. Through the micro grid control system, intelligent switching control can be realized for four key load branches, so as to achieve the purpose of energy saving and
peak load cutting. The micro-grid system has four key elements: source, network, load and storage. It is the epitome of a strong smart grid, and evolves the traditional one-way irreversible energy supply system to the energy Internet.

With the ubiquity of the Internet, the strong smart grid and the ubiquitous power Internet of Things coexist, the energy Internet is an inevitable trend. The strong smart grid on the supply side and the ubiquitous power Internet of Things on the demand side are “one supply and one demand” and are closely related and inseparable. In the long run, it will promote the coordinated interaction of source-network-load-storage, reduce the “three abandonment”, and effectively make up for the shortcomings of renewable energy development [10]. All the equipment and operating status data of the micro-network system will be intelligently collected, and the data transmission to the energy-efficiency monitoring platform will also provide technical support for the future realization of energy custody. Building distribution network in the distribution field and transferring data to the distribution Internet of Things is the next step.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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