Wind-Solar-Storage Linkage Allocation Algorithm for Carbon Neutral Energy Internet

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Abstract. Relying on the current situation of photovoltaic industrial park and comprehensive energy construction, the construction project of comprehensive energy multi energy complementary demonstration area was carried out in Changzhou high speed railway new town. Combined with the block chain technology pilot energy Internet construction, the core demonstration area of urban energy interconnection with horizontal multi energy complementary and vertical source network load storage coordinated regulation was constructed, which further improved the urban equipment energy consumption perception and clean energy consumption capacity. To achieve the goal of reducing the overall energy consumption and improving the comprehensive energy efficiency. To improve the perception level of urban comprehensive energy informatization, different types of energy collection, monitoring and operation and maintenance in the region are relatively independent, and there is a lack of centralized multi energy complementary dispatching system, so as to realize the panoramic monitoring and intelligent control of urban cold, heat, electricity, water, gas and other energy.

Keywords: Carbon neutral; The Energy Internet; Energy storage optimization; Probability of power supply loss; Total net present value carbon cost.

1. Introduction
There are a large number of flexible adjustable loads in the living area, business area and comprehensive area. [1] Through the construction of energy Internet and the operation regulation of self-sufficiency mode and interactive mode with power grid under the scenario of smart energy interconnection, [2] the project can reduce energy expenditure and improve the intelligent level of comprehensive energy management of the whole high-speed rail city. [3]

Through the pilot power market transaction of blockchain technology and the deployment of integrated energy gateway with blockchain function module, an integrated energy service model with the participation of high-speed rail station, power grid company and power sales company is constructed. [4] Through the construction of load virtual power plant, users are guided to actively participate in power market transaction, so as to reduce energy consumption cost and obtain additional demand response Electricity transaction and other expenses [5].

Through the integration of high-speed rail city comprehensive energy consumption, the integration of upstream and downstream equipment production, sales, operation and maintenance and other
manufacturers, build a comprehensive energy ecosystem, realize the further integration of multiple information of energy, people and property, further expand the vision of traditional business, explore new business growth points, and explore suitable business operation mode.

2. **Modeling of Energy Internet Components under Carbon Neutral Concept**

The load virtual power plant is constructed. Through the transformation of some flexible adjustable loads such as air conditioning, water heater, electric vehicle charging pile and part of lighting in the area, the peak release peak load regulating capacity is no less than 500kW. Some air conditioning and electric vehicle charging pile are further transformed into load virtual synchronous machine, and the peak release frequency regulating load capacity is no less than 100kW, the maximum climbing capacity is 50KW / min.

Deploy the integrated energy gateway of blockchain function module, build the integrated energy service model based on blockchain technology from three aspects of energy supply, energy consumption and service, and build the blockchain network architecture between different types of nodes such as energy, power grid (especially including power integrated energy service company and its own power sales company), power sales company (especially private type), users based on Multi Chain pilot, Ensure the efficiency, transaction security and real-time service of the negotiation mechanism of the integrated energy service system supported by the blockchain.

2.1. **Photovoltaic Energy Modeling**

LiFePO4 battery is used as the energy carrier of distributed energy storage:

\[
P_{PV} = Y_{PV} \times f_{PV} \left( \frac{G_T}{G_{T,STC}} \right) \left[ 1 + \alpha_p \times \left( T_c - T_{c,STC} \right) \right] \tag{1}
\]

LiFePO4 battery is also a kind of lithium battery, which is actually a branch of lithium-ion battery. It includes LiMn2O4, lico4 and ternary lithium battery. Its performance is mainly suitable for power applications. Therefore, the main advantage of LiFePO4 battery is that its security and stability may be better than other batteries in power supply applications.

\[
T_c = \frac{T_{a} + (T_{c,NOTC} - T_{a,NOTC}) \times \left( \frac{G_T}{G_{T,NOCT}} \right) \times \left( 1 + \frac{\tau}{1 + (T_{c,NOTC} - T_{a,NOTC}) \times \left( \frac{G_P}{G_{P,NOCT}} \right) \times \left( 1 + (1 - \alpha_p) \times T_{c,STC} \right)}{\tau} \right)}{1 + (T_{c,NOTC} - T_{a,NOTC}) \times \left( \frac{G_P}{G_{P,NOCT}} \right) \times \left( 1 + (1 - \alpha_p) \times T_{c,STC} \right)} \tag{2}
\]

Where \( T_c \) is the PV cell temperature (°C), \( T_a \) is the ambient temperature (°C), \( T_{c,NOTC} \) is the operating unit temperature (°C), \( T_{a,NOTC} \) is the ambient temperature (20°C) defined by NOCT, \( G_{T,NOCT} \) is the solar radiation (0.8 kW/m2) defined by NOCT, \( \tau \) is the transmittance (%) of the solar energy covering the photovoltaic array, and \( \alpha \) is the solar absorption rate (%) of the photovoltaic array. The product of solar absorption and solar transmittance is 0.9 or 90%.

2.2. **Wind model**

In some ways, it has more advantages than ternary lithium batteries and lead-acid batteries. First of all, LiFePO4 battery has better high temperature performance, which can withstand the temperature of 350 °C to 500 °C, while limno4 / Co2O3 battery is usually only about 200 °C. The material of the improved ternary lithium battery will also be at 200 °C. Secondly, LiFePO4 battery has longer cycle life than lead-acid battery and ternary lithium battery:

\[
\frac{v(x_{in})}{v(x_{an})} = \frac{\ln(x_{in}/z_0)}{\ln(x_{an}/z_0)} \tag{3}
\]
The "cycle life" of lead-acid battery is only about 300 times, and the maximum is 500 times; The theoretical life of ternary lithium battery can reach 2000 times, but the capacity will drop to 60% when it is used for 1000 times. The actual life of LiFePO4 and LiFePO4 batteries is up to 2000 times. At this time, they still have 95% capacity, and their theoretical cycle life can reach more than 3000 times.

2.3. Battery storage modeling

Compared with lead-acid battery, it has many advantages:

(1) Large capacity. 3.2V monomer can be made into 5Ah ~ 1000ah (1Ah = 1000mah), 2V monomer of lead-acid battery is usually 100Ah ~ 150Ah.

(2) Light weight. The volume of LiFePO4 battery with the same capacity is 2 / 3 of that of lead-acid battery, and its weight is 1 / 3 of that of the latter.

\[ C_{bat}(t) = C_{bat} \times (t - 1) \times (1 - \alpha) + \left( E_w(t) + E_p(t) - \frac{E_{r}(t)}{\eta_{inv}} \right) \times \eta_{bat} \]  

(4) Fast charging capability. The starting current of LiFePO4 battery can reach 2c, which can realize high-rate charging; The current demand of lead-acid battery is usually between 0.1C and 0.2C, so it is unable to realize fast charging.

\[ C_{bat}(t) = C_{bat} \times (t - 1) \times (1 - \alpha) - \left( \frac{E_{r}(t)}{\eta_{inv}} - \left( E_w(t) + E_p(t) \right) \right) \]

(5) Environment protection. Lead acid battery contains a lot of heavy metals, which will produce waste liquid. Lithium iron phosphate battery does not contain any heavy metals, so it has no pollution in production and use. (5) Cost effective. Although the materials of lead-acid batteries are cheap and the purchase cost is lower than that of LiFePO4 batteries, they are not as economical as LiFePO4 batteries in terms of service life and routine maintenance. The practical application results show that the cost performance of LiFePO4 battery is more than 4 times that of lead-acid battery.

3. Optimal matching method

3.1. Flexible load transformation

At present, the main charging technology schemes of electric vehicle charging system are contact type and non-contact type. Contact type is divided into: single-phase AC, three-phase AC, DC. Non-contact type with wireless charging. The industry development trend of charging technology: single-phase charging technology to three-phase charging technology development; Unidirectional charging technology develops to bidirectional charging and discharging technology; The charging mode has developed from manual charging to automatic charging; The expanded functions and value-added services of charging system are constantly enriched; On board charger (OBC) technology: the main function of on-board charger is to convert AC 220 V commercial power into high-voltage DC power (such as DC 400 V) to charge the power battery to ensure the normal driving of the vehicle. The equipment is AC / DC power conversion equipment. The vehicle charger and market pile are matched by communication, and the communication and power regulation are completed according to the national standard, which is GB /T20234.

\[ N_{w} = \frac{P_{\text{load ave}}}{P_{w, ave}} \]  

\[ N_{p} = \frac{P_{\text{load ave}}}{P_{p, ave}} \]
AC charging pile is a charging device that provides AC power for electric vehicles. Its basic composition: relay (contactor), controller guide circuit, leakage protection circuit, over-current and over-voltage protection circuit, lightning protection module. According to the number of guns, it can be divided into single gun and double gun. According to the capacity, it can be divided into 10A 220VAC (portable), 16A 220VAC, 32A 220VAC (market mainstream), 63A 380VAC.

DC charging pile is a device that converts AC to DC through internal AC-DC charging module to charge the power battery of electric vehicle. Output voltage class: 200-500vdc (passenger car), 350-750vdc (commercial vehicle), 200-750vdc (general purpose).

\[ E(t) = (P_{pv}(t) \times n \times \Delta t) + (\Delta t \times m \times P_{v}(t)) - (\Delta t \times P_{load}(t)) \]  

(8)

The fast-charging pile (plug) equipment adopts the structure of AC and DC integration. It can realize both DC charging and AC charging. When there are many charging services in the daytime, DC mode is used for fast charging. When there are few users in the charging station at night, AC charging can be used for slow charging.

3.2. Research on Carbon Economy

Because flexible load regulation is mainly based on air conditioning and electric vehicles, the specific strategies are as follows:

1. Air conditioning: special monitoring and control modules are deployed on the relevant equipment of the user's central air conditioning host system. Through the local server or remote workstation, the operating parameters such as the outlet water temperature and pump frequency of the central air conditioning host can be adjusted, so as to improve the energy efficiency of the air conditioning system and adjust the power load. Through the communication between the intelligent dynamic demand response terminal cabinet and the main station of the power supply company, the operation of the user's central air conditioning system can be monitored in real time, and the air conditioning load control instructions can be issued. Through the intelligent main control cabinet, it can realize the real-time monitoring and control of all kinds of equipment installed on site.

\[ C_{NFC} = \frac{C_{envtot}}{CRF(i,N)} \]  

(9)

2. Electric vehicle charging pile: relevant monitoring modules are deployed at the user end to monitor the charging pile status, charging status and vehicle battery status and upload them to the system in real time. In case of alarm or abnormal situation, corresponding control measures can be taken. In general, when there are many charging services in the daytime, DC charging can be used for fast charging. and when there are few users in the charging station at night, AC charging can be used for slow charging.

\[ i = \frac{t' - f}{1 + f} \]  

(11)

4. Carbon Neutral Case Study Based on Jiangyan Area in Taizhou

If the user substation has a perfect integrated automation system, the data required for measurement can be collected from the integrated automation system first. If the user is equipped with four in one protection measurement and control device without integrated automation system, he can directly
communicate with the protection measurement and control device to obtain data. If there is no special measurement and control equipment for user's low voltage bus voltage, it is necessary to add a multi-functional smart meter to realize the power acquisition of low voltage bus.

Table 1. Technical parameters of the PV panel

| Yp (W) | Ap (m²) | αp (%/°C) | fp (%) | Tc,NOCT (°C) |
|--------|---------|-----------|--------|--------------|
| 50     | 0.49    | -0.46%    | 95     | 41–45        |

For distributed photovoltaic power generation system, the current, voltage, power, frequency, power, energy and other parameters of the three-phase isolation transformer can be collected. Analyze the power status of photovoltaic power generation system, upload it to the energy collection terminal, and display it through the energy management platform. Different users can access it through Ethernet.

Multi energy complementary dispatching system is deployed to realize the panoramic display of urban energy topology. Through flexible load regulation, multi energy complementary and system interaction of source network load, the operation mode of energy flow is optimized to reduce the comprehensive energy loss by no less than 5% and the peak valley difference by no less than 10%; The low-voltage DC distribution network will be reconstructed and constructed in the living area, and the local small capacity distributed photovoltaic, energy storage and DC load access will be experimented to reduce the local comprehensive energy loss by not less than 5%.

As the main body of integrated service execution, power grid and power sales company can be divided into power supply business and other service business. Power supply business is the main service business. When the user sends the power supply business request from the power supply chain, the integrated service main chain of the user integrates the power demand information at the same time and broadcasts it to the main chain of the power grid or the main chain of the power selling company, waiting for the reply of the request.

The transaction needs the main chain of the power grid (or the main chain of the power selling company) and the dispatching slave chain to cooperate with the main chain of the source to achieve the power supply business Consistency of electricity price and dispatch; For energy-saving design, equipment maintenance and other services, the main chain of power grid (or the main chain of power sales company) and its integrated energy service slave chain reach the consistency of service transaction.

5. Conclusions
Focusing on the five types of energy in the planning area, such as cold, heat, electricity, water and gas, the panoramic perception of energy center, energy node and energy terminal was realized, and the core
demonstration area of urban energy Internet with horizontal multi energy complementary and vertical source network storage coordinated regulation was constructed. The supply side includes: photovoltaic power generation, wind power generation, gas source, heat source and power supply; The demand side includes four kinds of loads: cold, heat, electricity and gas; Multi energy coupling mainly refers to CCHP and other comprehensive energy consumption equipment; The storage side is the energy storage equipment of electricity, gas and heat storage. According to the unique cost advantage of Changzhou photovoltaic industry in the planning area, a distributed energy storage system of no less than 200kwh will be built in the Tianhe solar energy plant or the business hall of the power supply station in the area. Realize 30% consumption of local distributed photovoltaic power generation, pilot demand response and other projects, and guide users to save energy.

References

[1] M. H. BARECKA, J. W. AGER, A. A. LAPKIN. Carbon neutral manufacturing via on-site CO2 recycling [J]. iScience, 2021, 24(6):102–114.

[2] M. DAS, M. A. K. SINGH, A. BISWAS. Techno-economic optimization of an off-grid hybrid renewable energy system using metaheuristic optimization approaches – Case of a radio transmitter station in India [J]. Energy Conversion and Management, 2019,185(9): 339-352.

[3] D. B. EGGERTSSON. The Reykjavik Green Deal: on the carbon neutral city and public health [J]. The Lancet Planetary Health, 2021, 5(2):71–81.

[4] R. A. GUPTA, R. KUMAR, A. K. BANSAL. BBO-based small autonomous hybrid power system optimization incorporating wind speed and solar radiation forecasting [J]. Renewable & Sustainable Energy Reviews, 2015, 41(1):1366-1375.

[5] S. SINHA, S. CHANDEL. Review of recent trends in optimization techniques for solar photovoltaic–wind based hybrid energy systems [J]. Renewable & Sustainable Energy Reviews, 2015(10), 50:755-769.