Research on Comprehensive Energy Management System Technology

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Abstract. This paper studies the research status of the energy internet and integrated energy management platform, the analysis of the improvement of energy efficiency and economic efficiency of clean energy of distributed power, and the establishment of mathematical models for some parts of the energy management system and analysis to evaluate different types of pluri-tal complementary system of comprehensive benefits, from the three-dimensional aspects of economic, environmental and other aspects of system security level and the establishment of systems for comprehensive benefit evaluation system, and the various indicators and correlation tests standardization process. The case analysis of the proposed model is carried out to verify the effectiveness of the proposed evaluation model and the comprehensive benefits of the multi-energy complementary system in the park.

1. Introduction
Under the background of the new energy system revolution, it is imminent to strengthen the management of comprehensive energy bodies in the park, and scientific issues need to be sorted out urgently. Both the power system reform and the oil and gas system reform are carried out in accordance with the idea of "controlling the middle and letting go of both ends", focusing on the characteristics of market competition on the energy supply side and energy consumption side. For example, on the energy supply side, it is necessary to consider which operation mode and operation target to choose to establish the park operation mechanism, especially how to obtain the optimal game equilibrium strategy when different parties are in a non-cooperative relationship; on the energy consumption side, how to describe the different parties’ For energy consumption utility, establish different energy consumption price-demand response models for different subjects. Finally, consider how to establish a dynamic game mechanism between the energy supply side and the consumption side of the park that meets the characteristics of a competitive market. All of the above will become a key issue for the operation of the park under the new price mechanism, and urgent research is needed.

2. Research status of multi-energy complementary systems in the park
In Asia, Japan's energy reserves are very low because of the localization of the stone, the first to carry improve utilization efficiency of energy research traitor. In 2009, the Japanese government announced its co2 emission reduction targets for 2020, 2030 and 2050, and wanted to build a multi-energy complementary system across the country to realize the optimization of Japan’s energy use structure and the improvement of energy use efficiency, and promote to wind power, light V-based renewable energy in energy consumption accounted upgrade, achieve large-scale development of renewable energy sources [1].
In large-scale energy-consuming facilities such as new-type urban construction and new-type industrial parks, China has established coordinated optimization and coordinated planning of different energy systems in the field of energy consumption terminals with C CHP units as the core. Synergize traditional fossil energy consumption with energy use such as wind power and photovoltaics to improve system energy use efficiency and efficiency. The construction of a multi-energy complementary system in the park realizes the integration of energy sources such as electric energy, natural gas, and thermal energy. Through the use of big data technology and cloud computing technology, the complementary utilization and coordinated supply of multiple energy sources are realized. At present, the Chinese government is promoting the revolution in energy production and consumption, and promoting the large-scale utilization of renewable energy.

At present, the European Union, the United States, Japan and other countries and regions have launched pilot projects focusing on the utilization of integrated energy systems.

3. Research content

This article takes the multi-energy complementary system of the park as the research object and discusses the scheduling optimization and benefit evaluation mechanism with multi-agent participation. The main research contents are as follows:

(1) Analysis of the development status and operation characteristics of multi-energy complementary systems in the park The experience of implementing multi-energy complementary systems in Japan and other developed countries, combined with the current status of pilot construction and operation of multi-energy complementary systems in China, summarizes the experience of the implementation of corresponding pilots, and lays the theoretical foundation and practical experience for the follow-up research of the thesis.

(2) Optimized model of power generation dispatching in the park electricity-storage complementary system

The park's electricity-storage complementary system is mainly built on the terminal to build systems containing wind power, photovoltaic and energy storage. The thesis will optimize the overall benefits of the park's electricity-storage complementary system based on the wind power and photovoltaic output characteristics, and with the assistance of the energy storage system. Discussions Park - The basic strategy of complementary storage system operation, in order to maximize the overall effectiveness of the system as the objective function, considering the system operating constraints, renewable energy to run equipment constraints, storage equipment and systems operating constraints equipment with constraints. Light at a different set of confidence volts joint scheduling simulation scenario, for example the proposed model analysis, verification Park - The effectiveness of complementary storage system model.

4. Mathematical models

The battery situation, for characterizing the electrical energy storage device of a basic parameters which are: the energy storage capacity, charge / discharge rate, an energy storage device voltage, an energy storage device resistance, the SOC and energy storage equipment life. The following introduces the relevant parameters involved in the electric energy storage model in the electric thermal hybrid power supply system established in this article:

Equipment capacity

Equipment capacity is the most important indicator of the performance of electric energy storage equipment, and is a measure of the amount of electricity discharged by electric energy storage equipment under certain conditions.

(1) Charge / discharge rate

The charge / discharge ratio is the ratio of current during charge / discharge of the energy storage device.

\[ C = I / S0 \]
In the formula:
\( C \) — charge and discharge rate;
\( I \) — the value of the working current of the electric energy storage device during charging and discharging;
\( S_0 \) — rated capacity.

(2) State of charge (SOC)
The state of charge is also called the remaining power, which refers to the ratio of the remaining capacity of the electric energy storage device to its total capacity, usually expressed as a percentage. Its value range is 0 ~ 1. When SOC = 0, it means that the remaining energy of the electric energy storage device is 0, which means that the electric energy device is completely discharged. Similarly, when SOC = 1, it means that the remaining energy of the electric energy storage device is 100%. That is completely filled. The expression of the remaining energy \( E \) inside the electric energy storage device at time \( t \) is:

\[
E_{\text{surp}}(t) = (1 - \tau)E_{\text{surp}}(t - 1) + \left[ \eta_{\text{ch}} P_{\text{ch}}(t) - \frac{P_{\text{dis}}(t)}{\eta_{\text{dis}}} \right] \Delta t
\]  

In the formula:
\( E_{\text{surp}}(t) \) — capacity of electric energy storage equipment at time \( t \);
\( \tau \) — self-discharge efficiency of electric energy storage;
\( E_{\text{surp}}(t - 1) \) — Time period \((t-1)\) capacity of electric energy storage equipment;
\( \eta_{\text{ch}} \) — charging efficiency of electric energy storage equipment;
\( \eta_{\text{dis}} \) — Discharge efficiency of electric energy storage equipment;

\( P_{\text{ch}}(t) \) — Charging power of electric energy storage equipment in period \( t \);

\( P_{\text{dis}}(t) \) — Discharge power of electric energy storage device in period \( t \).

The electric refrigerator is a device that converts electrical energy into cold energy. The cold energy provided by it mainly depends on the energy efficiency ratio. Its model is:

\[
Q_{\text{EC}} = E_{\text{COOL}} \eta_{\text{EC}}
\]  

In the formula:
\( Q_{\text{EC}} \) — Electric cooling output;
\( E_{\text{COOL}} \) — The input energy of the electric refrigerator;
\( \eta_{\text{EC}} \) — Electric cooling conversion efficiency .

\[
T_{i+1}^{\text{inside}} = \varepsilon \cdot T_{i}^{\text{inside}} + (1 - \varepsilon) \cdot (T_{i}^{\text{outside}} - \eta \cdot \frac{Q_i}{a})
\]  

\[
Q_i = PP_{i\text{HVAC}} \cdot \Delta t
\]

Where: \( T_{i}^{\text{inside}} \) and \( T_{i}^{\text{outside}} \) distributions represent the indoor temperature and outdoor temperature of the \( i \)-th time slot, \( i \in \{1, 2, \ldots, I\} \) is the time slot number, \( \varepsilon \) is the inertia factor, \( \eta \) is the efficiency of the air conditioner, \( a \) is the heat transfer coefficient of the housing construction materials, \( Q_i \) is the air conditioning at the \( i \)-time slot consumption of energy consumption, which is equal to the time slot within the air-conditioning power \( P_i \) the HVAC multiplying the time slot length [Delta] \( T \).
Furthermore, the air conditioning running The power \( P_i \) HVAC should not exceed its rated power; and to ensure comfort, the indoor temperature should be controlled within the temperature range set by the user. The corresponding constraints are as follows:

\[
0 \leq P_{i\text{HVAC}} \leq P_{\text{max}}^{\text{HVAC}}
\]

\[
\tau_{\text{min}}^{\text{HVAC}} \leq \tau_{i}^{\text{inside}} \leq \tau_{\text{max}}^{\text{HVAC}}
\]

PV (Photovoltaic, the PV) solar radiation energy is converted into electrical energy by the photovoltaic power generation panels system, controller and energy storage and conversion link configuration. As shown in Fig. 1, the solar radiation energy can be directly converted into electrical energy through the photovoltaic panel. The electrical energy is stored and converted by the controller and energy storage unit, etc., and finally transmitted to the power grid to meet the load demand.
FIG 1. Photovoltaic cell equivalent circuit

RL is the electrical load supplied by the solar panel through photoelectric conversion to generate electrical energy; the terminal voltage UL is the load voltage; the output current IL is the load current; RS is the series resistance, which can generally be ignored; Rsh is the internal leakage impedance of the power supply, about Thousands of ohms. In order to simplify the analysis process of photovoltaic power generation, you can

RS is regarded as a short circuit, and the branch where Rsh is located is regarded as an open circuit; IPH is the current generated by the photon irradiating the solar panel, which is the current excited by the photon on the solar panel; IVD is the case where the light intensity is 0, The unidirectional current formed by the load voltage UL inside the PN junction, IVD is expressed as:

$$I_{VD} = I_0 \left(e^{\frac{qE}{AKT}} - 1 \right)$$  \hspace{1cm} (8)

Where q is the charge of an electron, is $1.6 \times 10^{-19}$ C, K - Boltzmann constant, A - a constant factor, a positive bias voltage is larger A is 1, a positive bias voltage hours A is 2, I0 is the diode reverse Saturation current. According to the above equation, the IVD size itself, and the electromotive force E and temperature T size.

IPH is affected by the irradiance of solar energy on the solar panel, the effective light area of the solar panel, and the temperature T of the solar panel. IPH is proportional to the irradiance of the incident light. When the temperature increases, the IPH will increase slightly.

The load current IL is:

$$I_L = I_{PH} - I_{VD} - \frac{UL + ILR_S}{Rsh}$$ \hspace{1cm} (9)

Rs is much smaller than RSH. When calculating the ideal circuit, the characteristics of the photovoltaic cell can be simplified as

$$I_L = I_{PH} - I_0 \left(e^{\frac{qUL}{AKT}} - 1 \right)$$ \hspace{1cm} (10)

$$P_{pv} = I_L U_L$$ \hspace{1cm} (11)

In the formula:

- $P_{pv}$ — The output rate of the photovoltaic panel;
- $I_L$ — Working current of photovoltaic cells;
- $U_L$ — The operating voltage of the photovoltaic cell.

The picture shows the PV characteristic curve of photovoltaic power generation. It can be seen from the figure that the output electric power curve of the solar cell is a power-voltage single peak curve with the maximum power point as the maximum value.
Figure 2 PV characteristic curve of photovoltaic power generation

The picture shows the IV characteristic curve of photovoltaic power generation. From the figure, it can be seen that the output current and voltage of the solar cell exhibit nonlinear characteristics. When the output voltage is relatively low, the output current is almost stable. Flow source.

The modeling of electric vehicles considers V2G and V2H functions, assuming that they can provide energy for peak household loads through reverse discharge, and defines the electric vehicle charging power as positive and discharging power as negative. Battery in electric vehicle charging / discharging state The state-of-charge model can be expressed by the following formula:

\[ SOC_{t+1}^{EV} = SOC_t^{EV} + u_t^{EV} \cdot \eta_{charge}^{EV} \cdot (P_t^{EV} \cdot \frac{At}{E_{max}^{EV}}) \] (12)

\[ u_t^{EV} = \begin{cases} 1, & \text{if } P_t^{EV} > 0 \\ 0, & \text{or } P_t^{EV} < 0 \end{cases} \] (13)

5. Conclusion

According to the characteristics of wind power and photovoltaic output, and with the assistance of the energy storage system, the overall benefit of the park's electricity-storage complementary system is optimized. Discuss the basic strategy of the park's electricity-storage complementary system operation, take the system's overall benefit maximization as the objective function, and comprehensively consider the system operation constraints, renewable energy equipment operation constraints, energy storage equipment operation constraints and system backup constraints. Light at a different set of confidence volts joint scheduling simulation scenario, for example the proposed model analysis, verification Park - The effectiveness of complementary storage system model.

References

[1] G. Wood, M. Newborough. Indicators for the Dynamic Energy consumption-Domestic Appliances: Environment, Behavior and Design [J] Energy &amp; Buildings, 2003,35 (. 8).

[2] Pooya Arbabi, Abbas Abbassi, Zohreh Mansoori, Mohammad Seyfi. Joint numerical-technical analysis and economical evaluation of applying small internal combustion engines in combined heat and power (CHP) [J]. Applied Thermal Engineering, 2017, 113.

[3] M. Parsa Moghaddam, A. Abdollahi, M. Rashidinejad. Flexible Demand Response Modeling Programs in Competitive Electricity Markets [J]. Applied Energy, 2011,88 (. 9).

[4] Erdinc O, Paterakis NG, Mendes TDP, et al. Smart household operation considering bi-directional EV and ESS utilization by real-time pricing-based DR [J]. IEEE Transactions on Smart Grid, 2015, 6 (3) : 1281–1291.