Research on Comprehensive Energy System Analysis Platform of Typical Park

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Abstract. In order to improve the efficiency and accuracy of the comprehensive energy system scheme planning, the research and development of the comprehensive energy system analysis platform in the park was developed. Take the construction of parks (including building parks and industrial parks) as an entry point. Theoretical research is carried out on three aspects of the overall scheme design method of the comprehensive energy system of the park, the influencing factors and analysis methods of the comprehensive energy projects in the park, and the construction of the smart energy integrated management platform. Based on the theoretical research results, the corresponding development of platform tools is proposed, and the platform tools are used to support the planning and design of the integrated energy system of the park and the analysis of investment and operation benefits. The platform research results show that comprehensive energy schemes can be automatically generated and improve accuracy and efficiency. The research results have certain reference and guidance value for the construction and operation of comprehensive energy projects in the subsequent parks.

1. Introduction

The multi-energy complementary comprehensive energy system (hereinafter referred to as the "integrated energy system") is a regional energy supply centered on and distributed around distributed renewable energy, natural gas trigeneration and energy intelligent microgrids. It is a form of energy supply that combines cold, heat, electricity, gas and water. On the one hand, the integrated energy system improves the utilization rate of renewable energy through the realization of multi-energy collaborative optimization and complementarity; on the other hand, through the realization of energy cascade utilization, the comprehensive utilization of energy is improved.

The park, as an aggregate of energy-using units such as factories, commercial buildings, logistics and warehousing, etc., has always accounted for a high proportion of the country's total energy consumption. Although the traditional park energy supply method has the advantage of stable energy supply, it cannot use energy in a cascade, which restricts efficient energy use and causes a large amount of energy loss. Therefore, the development of multi-energy complementary comprehensive energy projects in important industrial economic zones or commercial and office integrated industrial parks has become the first choice for many enterprises.
Through the investigation of many typical multi-energy complementary comprehensive energy projects implemented in the early days in China, with the exception of some relatively mature projects, most of the current multi-energy complementary parks have not achieved satisfactory overall operating benefits. Many growth pains such as profit bottlenecks and low level of information management. But even so, due to the diversified energy demand of the park and the existence of a large amount of load, the application of "Internet +" smart energy-related technology concepts to carry out comprehensive energy business in the park is still the mainstream development trend and hot spot in the future.[1-2]

2. Functional positioning of integrated energy system analysis platform

2.1. Platform positioning
At present, the development of integrated energy projects faces a problem, that is, most non-professional customers do not know much about the concept of "multiple energy complementation" or "integrated energy", specific application scenarios, and advantages. Therefore, the enthusiasm for investment and construction is not high, which hinders the development of comprehensive energy to a certain extent. Under such a background, by developing corresponding platform tools, customers can visually perceive the full business process of integrated energy projects through scenario simulation on the one hand, and by performing comprehensive benefit analysis on integrated energy projects under planning on the other. Help clients understand investment and returns. This thesis studies the analysis platform of a typical park integrated energy system, hoping to actively promote the concept of multi-energy complementation by means of "Internet +".

The platform's main positioning is: based on integrated energy project planning and designing business processes and related technical and economic models, using planning data, energy demand data, and energy supply equipment data, Design comprehensive energy project system schemes, and visualize simulation scenarios of integrated energy project business scenarios to realize investment income analysis of comprehensive energy projects.

2.2. Platform functions
Specifically, the development of integrated energy business puts forward the following core requirements for participating units in the industry. The first is scenario identification, that is, through project scenario characteristic parameters (such as resource endowment, etc.), analyze the key elements and basic principles of business development. The second is the scheme configuration, that is, based on the project scenario, to efficiently and quickly provide an overall scheme with reasonable technology and suitable economics. The third is economic evaluation, that is, to demonstrate in detail the economic benefits of the project to all participants, to ensure that the project is feasible; the fourth is to analyze the operation, that is, to accurately simulate the actual operating conditions and strategies of the project, and to improve the level of project operation and management.

Aiming at these needs, the functional positioning of the park's integrated energy system analysis platform is as follows: Setting of basic information in the park; Quantitative analysis of various types of energy demand in the park; equipment selection and optimization configuration on the energy supply side, transmission side and platform side of the park; Project investment benefit analysis; operation simulation under different operating conditions of the integrated energy system. [3-5]

3. Integrated Energy System Analysis Platform Architecture

3.1. overall platform architecture
The integrated energy analysis platform is mainly divided into six business function module designs according to functional requirements, which are the park's basic information, energy supply side, demand side, transmission side, platform side, and scenario analysis; The main business applications include park information setting, equipment information setting, power load analysis, cooling and
heating load analysis, configuration combination, and project benefit analysis. The platform architecture is shown in Figure 1 and Figure 2.

**Figure 1.** Overall model framework

**Figure 2.** Diagram of front / back ends of platform
3.2. Platform sub-function module

1) Park basic information setting function module
   Including geographic information and resources and environment information of the park, geographic information. Basic energy information includes key information such as power purchase price, electricity sales price, natural gas price, biomass price, diesel price, effective utilization hours, voltage level, etc. Supports users to set information by themselves.

2) Functional module for energy demand analysis
   The demand side is divided into electricity, cooling and heat load analysis. According to the parameters such as the area of the park land filled in by the user, the platform's background automatically calculates the area of various types of land, and calculates the power, cooling and heat load requirements of the park based on the load density method.

3) Function module on energy supply side
   Analyze the power parameters and cost of various energy supply equipment such as cold, heat, electricity, storage, etc. It is configured and displayed on the platform to realize the selection of comprehensive energy project equipment in different park scenarios, and it is possible to make selection and configuration recommendations based on the resources of the park.

4) Function module on the transmission side
   The transmission side is divided into various types of pipelines, including distribution networks, cooling pipelines, heating pipelines, natural gas pipelines, and comprehensive pipe corridors, which can be added and combined by users. Through the transmission side analysis, the platform's background economic benefit analysis model can be used to calculate the cost based on the transmission side pipeline and network costs.

5) Platform-side function module
   The platform side is mainly a comprehensive energy and energy information management platform, which plays the nerve center function of monitoring and analysis in the project. The platform economic benefit analysis model can be used for cost calculation based on the platform side cost.

6) Functional modules for solution optimization
   The user can generate different energy supply schemes by changing the equipment combination mode, installed scale, etc. and make a comparative analysis. The key index parameters of the scheme data table help the user to choose the optimal energy supply scheme.

7) Scene simulation
   According to the selection and configuration scheme, animation production and consumption are performed, and the comprehensive energy system complementary mechanism under different load scenarios is simulated. The scenario simulation mainly includes scheme equipment details, key index information and complementary mechanisms. The details of the scheme show the animation interface of the comprehensive energy scheme operation; the complementary mechanism is shown with dynamic diagrams showing the energy utilization and production under different load scenarios such as morning, afternoon, and night. [6-8]

3.3. Platform Features

1) According to the province and city where the project is located, set specific energy consumption information, such as electricity purchase price, natural gas price, biomass price, etc. The simulation results are closer to the actual situation.

2) Users can choose the park address, local resource endowment, energy supply equipment required by the project according to the actual situation of the project, and customize the energy supply plan. It also analyzes the benefits of multiple selection schemes, so that users can choose the most suitable scheme.

3) Scene effect display:(1) Use dynamic charts to show the supply and demand, energy storage status, and carbon emissions in the morning, afternoon, and evening; (2) Project economic indicator data: static investment, investment payback period, internal rate of return and other intuitive reflections, users can determine the feasibility of the scheme according to the specific operation of the technical scheme.
Combining the front-end three-dimensional visualization graphics and background configuration models and algorithms, it dynamically displays the composition and benefits of the smart park, and reflects the feasibility of the project intuitively.

4) Through the front-end display interface to support different customer needs, support simulation analysis and simulation in different scenarios. Customers can compare the evaluation results of different equipment configuration schemes and choose the best scheme quickly, so as to provide customers with professional and timely energy supply suggestions.

4. Business logic of integrated energy system analysis platform

4.1. Platform business logic
The operation flow of the platform is based on a logical sequence of energy demand analysis, energy supply scheme design, energy supply scheme optimization, and scenario simulation. Energy demand analysis mainly includes cold, heat, and electrical load forecast analysis of smart parks; the energy supply scheme design mainly includes equipment selection, equipment installation selection, etc.; the energy supply scheme optimization is mainly based on factors such as minimizing static investment, maximizing benefits, maximizing internal rate of return, and minimizing cost recovery period; the scenario simulation mainly focuses on the multi-energy complementary mechanism in each load scenario, as shown in Figure 3. [8-10]

![Figure 3. Platform operation flow](image)

4.2. Platform business model
The construction of the platform model is mainly aimed at the following issues: demand-side accurate analysis, optimal configuration of multiple energy solutions on the supply side, adaptive matching of the transmission-side solution, and economic analysis that fit the actual working conditions. These issues are the key links in the design of integrated energy solutions, and reasonable modeling can ensure the correctness of the solution design process.
4.2.1. **Planning Model of Land Use Area.** Parameter input: Land area of the park (10,000 square meters).
   Model output: Output of residential land, public management and service facility land, commercial service industry facility land, industrial land, logistics and storage land, road and transportation facilities land, public facilities land, green space and square land area (10,000 square meters).

4.2.2. **Building area planning model.** Parameter input: The area of various types of land in the previous step.
   Model output: residential land, public management and service facility land, commercial service facility land, Construction area of industrial land, land for logistics and storage, land for roads and transportation facilities, land for public facilities, land for green space and squares (10,000 square meters).
   Model algorithm: Based on the planning of each type of land area in the park, multiply by the plot ratio to calculate the building area of each type of land.

4.2.3. **Electricity, heat and cooling load model of the park.** Parameter input: The construction area (10,000 square meters) of various types of land.
   Output: Various types of land use load (MW).
   Model algorithm: Using the load density method, based on the electricity, heat, and cold indicators, multiply each type of building area to obtain the various types of land load.

4.2.4. **Total power consumption model of the park.** Model input: Effective utilization hours (h).
   Model output: Total park electricity consumption (kWh).
   Model algorithm: The total power consumption of the park is multiplied by the effective utilization hours to obtain the total power consumption.

4.2.5. **Distributed Energy Allocation Scheme Model.**
   3. 2. 5. 1 photovoltaic power generation configuration model
   The installed photovoltaic capacity per square meter is 50 to 70 W, and the effective hours of photovoltaic use are 900 to 1,300 hours.
   Model output: photovoltaic installed scale (MW), photovoltaic power generation (GWh), total photovoltaic cost (10,000 yuan).
   Model algorithm: The installed capacity is multiplied by the effective utilization hours to obtain the power generation amount; the installed size is multiplied by the photovoltaic unit cost to obtain the total cost, of which the annual unit cost defaults to 6,000 yuan / kW.
   3. 2. 5. 2 Model of tri-generation configuration scheme
   1) According to the total heat load of the park, combined with the heating capacity parameters in the model table of the tri-generation power supply, select the “triple-heating supply scale” configuration scheme by “heat-fixed electricity”
   a) Tri-generation supply can be combined with multiple models, with a total number of no more than three.
   b) The combined heating scale of all models of the tri-generation power supply is ≤ the total heat load of the park (which can be infinitely approached but cannot be exceeded).
   c) 0.5 units cannot occur, they must be integer units
   2) The configured triple power supply plan can output the following parameters: installed scale of triple power supply, scale of triple power supply
   3) When the following conditions are met:
   When the user selects any one or more of wind power, biomass, and diesel, the following cycle is entered, otherwise no adjustment is made.
   Total calculation formula: total electrical load in the park × 50%-photovoltaic installed capacity-triple supply installed capacity = remaining installed space.
The general premise is to satisfy: the scale of the tri-generation supply + photovoltaic installation ≤ total electrical load of the park × 50%.

If the remaining installed space is less than or equal to 0: If the photovoltaic installation scale at this time ≥ the total electrical load of the park × 50%, the photovoltaic installation scale is set to 80% by default to meet the above general premise; If after 80%, the total prerequisites are still not met or the installed photovoltaic scale is less than the total electrical load of the park × 50%, reduce the scale of the triple supply installation.

4) Processing logic to reduce the scale of the triple supply installation

A maximum of three tri-generation models can be combined. The principle is that the combined heat supply scale of all tri-generation models ≤ the total heat load of the park (which can be infinitely approached but not exceeded).

a) If the installed capacity of the triple supply is already the minimum power generation capacity and there is only one, the installed capacity selection of the triple supply is not adjusted.

b) Choose the scheme with the smallest unit investment

Unit investment (yuan) = installed scale of triple supply × 1000 × unit cost of triple supply

Unit cost for triple supply = 10,000 yuan / kW, 1000 refers to unit conversion

In one of the most extreme cases, the installed photovoltaic capacity is <the total electrical load in the park × 50%, and the size of the triple supply installation has been the smallest and only one. At this time, the remaining installed space is still less than or equal to 0, so the PV installation scale is set to 60% by default; Until the realization of the remaining installed space> 0 and the remaining installed space ≥ total electrical load of the park × 10%; when the remaining installed space> 0 and ≤ total electrical load of the park × 10%; remaining installed space = wind installed capacity + biomass installed capacity + diesel installed capacity.

c) Make sure that: the total installed scale of the three after installation is less than or equal to the total electrical load of the park × 10%; if the sum of the three exceeds the conditions, the three installed scales are averagely reduced in proportion.

4.2.6. Economic Evaluation Model. The economic evaluation algorithm model assumes that the project construction period is 1 year, the operation period is 25 years, the depreciation period is 25 years, the benchmark rate of return is 8%, and the loan interest rate is 4%. The loan accounts for 80% of the total investment, the loan duration is 10 years, the residual value rate of the project is 5%, the sales expense ratio is 5%, the value-added tax rate is 16%, and the income tax rate is 0.25%. VAT and income tax benefits.

5. Conclusion
This article develops and researches the integrated energy system analysis platform, and builds the model of the configuration, operation optimization, and economic benefit analysis of the energy supply side, transmission side, platform side, and energy use side of the integrated energy system. And according to the actual needs of the application scenario, the use of information technology and intelligent algorithms to automatically generate a comprehensive park energy planning and design plan. The research results modeled and implemented the entire process of the planning and design of the integrated energy system plan, thereby realizing the intelligent customization of the integrated energy plan, which has a strong guiding significance for the early design of the integrated energy project. The research still has room for optimization in terms of solution refinement and classification, which needs to be further improved and optimized in subsequent work.

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