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Regional Distributed Energy System Planning Based on Integration Theory

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Abstract: In many countries and regions, distributed energy systems have become a mature energy-saving technology. The system has the characteristics of being close to users, making full use of energy, protecting the environment and providing reliable power. The purpose of this paper is to study regional distributed energy system planning based on integration theory. The regional energy planning should be carried out according to the following steps. First, predict the regional load, then determine the available resource conditions of the region, evaluate and analyze the supply side of the region, and select a reasonable energy allocation plan according to the analysis results. Based on the energy planning of the region, an optimal allocation model based on the maximum net benefit function is established. It can be seen from the analysis of the actual cases of residential quarters that the annual income is kept at the maximum when the load characteristics of cooling and heating users are known.

1. Introduction

In recent years, with the rapid development of my country's economy, society, culture and other aspects, people's quality of life has been improved, and it is particularly important to realize the substitution of clean energy such as electricity in energy consumption [1-2]. The Regional Integrated Energy System (RIES) can not only increase the proportion of clean energy use, but also realize the efficient use of energy by coordinating energy generation, transmission, distribution and other links, and has become a strategic choice for most countries in my country and the world [3-4]. The unified planning and coordinated operation of each energy system can effectively make up for the shortcomings of separate planning and independent operation in the past [5].

The increasing popularity of distributed energy sources in distribution grids is causing a growing interest in using the flexibility offered by said distributed resources as an enhancement for distribution network operators. Olivella-Rosell P presents an optimization problem that can meet the flexibility requirements of distribution system operators. This is a decision problem for dispatching flexible energy by a new type of aggregator called Smart Energy Service Provider (SESP). The tests carried out yielded positive results and demonstrated the effectiveness of the proposed solution [6]. Ferraz R conducted a specific study on the operational and physical constraints of systems and generators to optimize the placement of DERs in distributed feeders to reduce investment and operating costs. Furthermore, taking into account generation and load variations during the day, DER operating patterns and all fault types, optimized recloser-fuse coordination is performed to reduce the activation time of these protection devices. The optimization method adopted is a genetic algorithm, and an IEEE 34 node test feeder is used to validate the proposed method. This scheme is able to simultaneously coordinate the protection devices of all the analysis cases [7]. Therefore, it is necessary to conduct in-depth research on regional distributed energy system planning and other aspects considering integration theory.

This paper mainly studies the planning of regional distributed energy system. Planning is the rational and scientific arrangement, planning and arrangement of energy in a specific area. District energy planning, in a word, is the activity of planning and configuring the built environment energy system in the study area. In order to solve the uncertainty of new energy, an energy storage device has been established, which plays the role of maximum regulation and valley filling. It is used as load energy storage at night, and energy is provided as energy during the day. Finally, a typical residential area is taken as an example to verify the effectiveness of the model.

2. Research on Regional Distributed Energy System Planning Based on Integration Theory

2.1. Steps of District Energy Planning

(1) Analysis of regional basic conditions

The analysis of regional basic conditions includes the analysis of the basic conditions of local power supply, gas supply and water supply, in which regional power supply includes power supply, the number and capacity of transformer stations, etc.; regional gas supply includes gas source type, location, quantity and capacity, etc.; Regional water supply includes water supply source, water supply quality and water supply quantity. The methods of understanding local basic conditions include on-site questionnaire surveys, on-site surveys, etc. By mastering the regional basic conditions, a certain foundation will be laid for the selection of energy systems in the future [8-9].

(2) Analysis of regional renewable energy utilization

The available resource conditions of a region include two aspects, one is the type of energy options, and the other is its availability [10]. The choice of the former renewable energy includes solar energy, geothermal energy, wind energy and other renewable energy, which resources are used and the proportion of each resource in the regional energy supply [11]. The latter emphasizes the availability of resources. For example, when batteries are used in solar photovoltaic power generation systems, their power generation cannot be estimated by the number of hours of sunshine per year [12].

(3) Select the appropriate energy allocation scheme

In my country's existing planning system, electricity, gas and water are the main energy supplies [13]. On the one hand, other private and foreign companies are not allowed to enter, and on the other hand, they grab market share for profit. For example, gas companies are involved in the field of air conditioners, and power companies are involved in heating The market will inevitably lead to double calculation of load, resulting in excessive use of conventional energy and unnecessary waste [14]. Therefore, in order to coordinate the municipal energy supply department, the choice of the appropriate energy allocation scheme is particularly important.

2.2. Application of Integration Theory in Energy System Planning

The concept of "integration" can be understood as the act or process of combining two or more elements into an organic system. The combination of these elements is not a simple situation or combination, but a combination of scientific knowledge and certain laws.

Integrated system management refers to the application of integrated thinking to system management, that is, the management thinking is guided by the integration process, the system is based on the integration process, and the management method is based on the integration method. In particular, through scientific and creative thinking, we can deal with various resource elements from a new perspective and level, expand our business vision, improve the integration of various business elements, and improve the order of business entities [16-17].

Similar to the concept of "integration", the design and management of power system is not a simple superposition of management elements, but is constructed and combined according to certain integration principles and standards through selection, compliance and better management elements. The planning and management of the power system requires systematic consideration, clarifying the roles and interdependencies between functions, establishing an appropriate communication and coordination platform, balancing the relationship between various objectives, and fully understanding the overall objectives of the system.

2.3. Distributed Energy System

The basic components of distributed energy systems are power generation equipment and waste heat utilization equipment, as well as pipeline connection systems and intelligent control systems [18-19].

Distributed energy systems work by burning high-pressure gas/fuel to drive generators to generate electricity, or use fuel cells or other technologies to provide electricity. Provides electricity, cooling, and heating to nearby buildings, as shown in Figure 1.

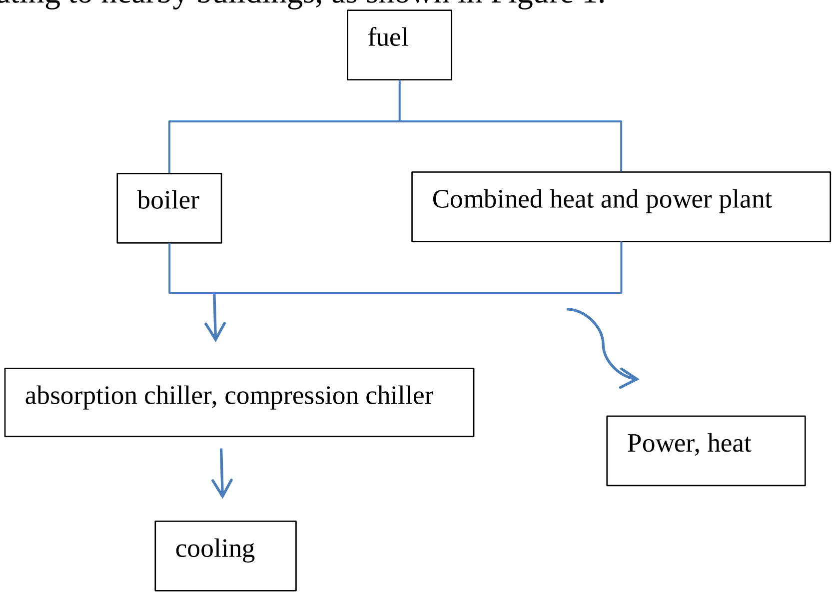

Figure 1. Distributed energy system diagram

Distributed energy systems have fewer users, low installed power, and small footprint, saving initial investment. Users can choose to invest in the construction of small distributed energy systems according to their needs.

The main equipment of the distributed energy system is scattered and can be conveniently arranged according to the situation, and the system equipment can be maintained independently without affecting the continuity of the power supply.

There are a wide range of fuel options for distributed energy systems. According to the characteristics of the project site, a convenient and stable fuel source is selected nearby, and the main materials are selected according to the fuel.

3. Investigation and Research on Regional Distributed Energy System Planning Based on Integration Theory

3.1. Establishment of System Optimization Model

Compared with the large power grid and heat pipe network, the distributed integrated energy supply system is a relatively independent whole, and the connection with the outside world is weak. In terms of electricity, the integrated distributed energy supply system conducts two-way transactions with the power grid; the heating network energy supply system has three energy supply forms, and the specific composition is shown in Table 1:

Table 1. Energy components

Form of energy supply	Composition
Multiple supply units	Gas turbines, photovoltaic cells, double-effect absorption units and heat exchangers
Single supply unit	Fuel cells, boilers, electric compression refrigeration units
Energy storage device	Energy storage device

The above energy supply together with the local power grid and heat pipe network constitute a local energy supply system to meet the local energy demand.

3.2. Optimal Configuration Model of Distributed Energy Integrated Energy Supply System

As the objective function, use the maximum value of the energy supply revenue above the total annual system cost (operating, maintenance, fixed):

$$\max f(Q_{DAC}, Q_F, Q_{GB}, P_{GT,re}, P_{MCFC}) = f_{benefit} - 10000 \cdot f_{gd} - f_O - f_M \quad (1)$$

The constraints are:

(1) The total design capacity of each unit must have a threshold value which should be greater than or equal to the load value.

(2) The double boiler receives hot water heating, which shall not be less than the design capacity of the PGN gas turbine and solar collector.

(3) The power of the energy storage device is affected by the power of PLmax and known power, including peak conditions and interruption conditions in the system.

$$\begin{cases} P_{D,\max} \leq P_{D,\max} + P_{PV} + P_{MCFC} \\ Q_{D,\max} \leq Q_{DAC} + S \cdot Q_F + (1-S) Q_{GB} \\ Q(P_{GT,re}) + Q_{PV,re} \leq Q_{DAC,re} \end{cases} \tag{2}$$

S=1 means summer, S=0 winter, Qre is the remaining capacity of the equipment, namely the rated capacity.

4. Analysis and Research of Regional Distributed Energy System Planning Based on Integration Theory

We take the residential area as the research object to realize the transformation of the distributed electric cooling and heating integrated system in this area.

According to the demand law of cooling and heating electricity load of users in residential areas, the annual unit usage hours of the units in the system (distributed energy integrated power supply system units, other main and auxiliary power supply units) can be obtained as shown in Table 2:

Table 2. Estimated Equipment Utilization Time

Season	Gas turbine	Solar unit	The fuel cell
Summer	2574	864	383
Winter	2075	665	543
Autumn and winter	1054	438	211

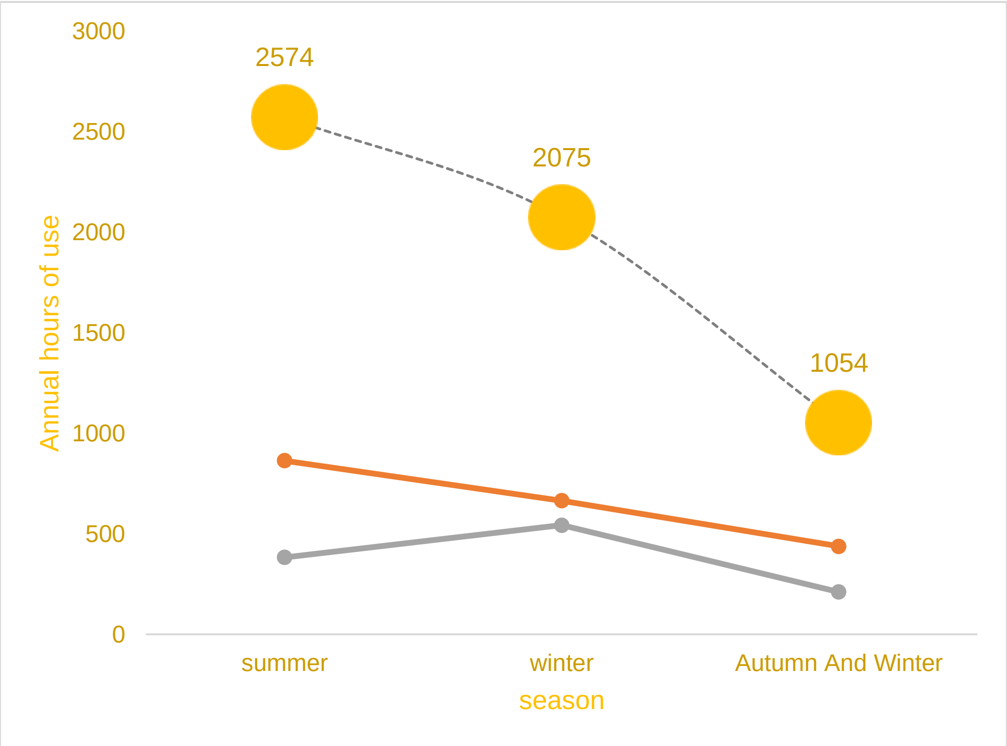

Figure 2. Annual equipment utilization hours

Gas turbines are the main category, with the highest annual operating hours; fuel cells, as public power sources, must work all year round, and the average annual use hours are high, as shown in Figure 2; as auxiliary equipment for heating and cooling energy, gas boilers and electric chillers only Used in winter and summer, the rate is low throughout the year. However, considering the climatic characteristics caused by the geographical location, the heat in the south exists for a long time, so the use time of the latter is longer than that of the former, and the consumption rate is higher.

Using Matlab software for simulation, the results are shown in Table 3:

Table 3. System unit capacity optimization configuration results

Unit type	Gas boiler(MJ)	Double-effect absorption unit(MJ)	Gas unit(kW)	Solar collector(MJ)
Design capacity	10864	8053	1975	458
Unit type	The fuel cell(kW)	Electric Compression Chiller(MJ)	PV(kW)	Energy storage device(MJ)
Design capacity	264	26421	185	3743

The cost of the distributed power supply system and the traditional method of short supply are calculated according to actual cases under the same conditions and the same planning period, ensuring that the cooling and heating distributed power supply system is economical in major economies.

5. Conclusion

How to improve energy utilization efficiency and reduce environmental pollution is the main problem faced by our country to realize sustainable development strategy. In the context of the grid-connected operation of the distributed energy integrated energy supply system, this paper establishes the optimal configuration model of the distributed energy integrated energy supply system from the perspective of the optimal configuration and economic operation of the distributed integrated energy supply system. Based on the research background of energy Internet, the distributed energy supply system and its application are studied, the traditional power distribution method is extended to the distributed energy system based on power cascade, and the cooling and heating are realized. Dynamic balance of energy and real-time balance of electrical energy.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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