Research on Optimized Configuration of Microgrid with Distributed Energy in Commercial Users in Hainan Province

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Abstract. The paper research object is the microgrid of commercial users in Hainan Province. Based on local power load, illumination and other related data, by using Homer Grid Software, the paper builds the model focusing on the microgrid composed of solar energy and battery. The paper simulates different economic operation plan and eventually select the most economical microgrid networking solution. Compared with the traditional grid power supply mode, we can see that the power generation cost of the optical storage microgrid system is greatly reduced. Zero emissions of pollutants are realized, which protects the ecological environment.

1. Introduction

In the face of energy crisis and global warming, people realize that the traditional fossil energy (oil, gas, coal, etc.) is no more sustainable to the economic growth. In order to achieve the long-term development, scientists and governments put a great emphasis on renewable and environment-friendly energy resource. [1, 2].

In 2017, the Hainan Provincial People's Government issued the 13th Five-Year Plan of Energy Development in Hainan Province. Three years later, non-fossil energy accounts for 17% of total energy consumption and the proportion of clean energy installed capacity increased to about 50%[3]. Hainan has a very good condition in solar energy development. The development and utilization of solar energy is appropriate to Green Development Strategy and Low Carbon Development in Hainan province.

In order to meet increasing demands of personalized and specialized use of electricity, considering the comprehensive utilization of different types of large-scale distributed energy, establishing a multi-energy complementary new power grid structure form, which means the micro-grid, is an important direction for the development of distributed power supply technology. Micro-grid refers to a small-scale power distribution system that is a collection of distributed power sources, energy storage units, energy conversion devices, related loads and monitoring and protection devices. It is an autonomous system that can achieve self-control, protection and management [4]. For large power grids, the piconet can be viewed as a single, controllable unit that can be operated in parallel or independently. China's theoretical research and engineering application of microgrid technology are still in their infancy. The unique role and feasibility of the microgrid has been highly valued and fully recognized by domestic experts and scholars. The microgrid system can make full use of clean distributed power generation resources, improve energy utilization, and enhance the reliability of regional power grids, which is a powerful complement to the power supply of large power grids.

This paper takes a micro-grid of a small business user in Hainan Province as the research object. The paper simulates different economic operation plan and eventually select the most economical
microgrid networking solution. Compared with the traditional grid power supply mode, the power generation cost of the optical storage microgrid system is greatly reduced. Zero emissions of pollutants are realized, which protects the ecological environment.

2. The working principle of HOMER Software
HOMER is a software developed by the National Renewable Energy Laboratory (NREL) for the evaluation and optimization of microgrid power generation systems. It is designed and optimized for networking or autonomous distributed generation functional systems. Based on cost and resource availability, a number of energy component models can be used to simulate the economic results and behaviour of various embedded power supplies through policy control, and finally make appropriate technology choices [5]. The HOMER software compares the combination of different component sizes and quantities and can study the impact of the availability and cost of the system on the installation and maintenance costs of different system designs. The user can first build the microgrid model, then input the load and distributed power related parameters, and finally enter the calculation module to calculate the microgrid economic scheme [6].

HOMER Grid is a new software separated from HOMER on March 1, 2018. The operation method is similar to that of HOMER Pro. Due to HOMER Grid's unique policy incentive model and real-time electricity price calculation, it is more suitable for business users. Although China's electricity market incentives are limited to power supply enterprises and rural poverty alleviation projects, clean energy incentives for ordinary small business users have not yet been introduced, and the electricity market has not yet been able to achieve real-time pricing. As the electric power reform is deepening and the clean energy is promoting, this function is of great significance in the application research of distributed energy microgrid in China.

3. Microgrid Modeling Based on HOMER Grid

3.1 Load analysis and data entry
The microgrid power generation system must first ensure the reliability of the load power supply. Secondly, to improve the utilization efficiency of renewable energy as much as possible, it requires a reasonable optimization of the form and capacity of renewable energy [7].

Hainan Island is located in the tropical north margin and belongs to the tropical monsoon climate. The annual average temperature is 23.81°C. The accumulated temperature which is greater than or equal to 10°C, is 8200°C. The coldest January temperature is still 17~24°C. For 1750 ~ 2650 hours, the light rate is 50% ~ 60%. The light temperature is sufficient and the photosynthetic potential is high [8]. Using the database data of the US NASA website in HOMER Grid, the monthly average temperature in Haikou and the solar radiation forecast data for one year are shown in Table 1.

| Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|------|------|------|------|-----|-----|-----|------|------|------|-----|-----|
| 19.30 | 20.33 | 22.41 | 24.51 | 25.93 | 26.63 | 26.52 | 26.40 | 26.00 | 24.91 | 22.64 | 20.11 |

| Daily Temperature(°C) | 0.415 | 0.407 | 0.436 | 0.48 | 0.483 | 0.483 | 0.505 | 0.474 | 0.443 | 0.429 | 0.423 | 0.398 |
| Clearness Index | 3.12 | 3.46 | 4.21 | 5.05 | 5.27 | 5.30 | 5.50 | 5.03 | 4.39 | 3.78 | 3.26 | 2.86 |
| Daily Radiation (kWh/m²/day) | 3.26 | 2.86 |

Due to the high temperature in Hainan Province, commercial users such as hotels, private hospitals, and 24h convenience stores require cooling equipment such as air conditioners even at night. Except for the period from November to December every year, the temperature in the night from January to February is pleasant, and the power consumption at night may be reduced. The electricity consumption at night for the remaining 8 months is basically the same. Users such as shops use electricity
throughout the year and generally manage them centrally. Therefore, it is beyond the scope of this article. Combined with temperature data, the power load is compiled as shown in Figure 1.

![Figure 1. Power load](image)

### 3.2 Microgrid modeling

The object selected in this paper is the urban commercial user. Considering the environmental conditions in the urban area, if we select distributed energy equipment, the wind power equipment with large requirements on the site is not necessary. At the same time, considering the potential risks of fuel storage, diesel generators have not been added to the microgrid system. The main components of the system are solar photovoltaic panels, lithium battery energy storage equipment and inverters. Their model parameters are shown in Table 2.

First, the solar photovoltaic panel is set to 40 blocks due to the need of site laying. Secondly, the battery provides a single voltage of 12 volts. To meet the needs of some facilities, the minimum number of series is set to 19. Figure 2 is a structural diagram of the microgrid in the example.

| Table 2. Optical storage model parameters. |
|-------------------------------------------|
| model          | Photovoltaic | Battery       | Inverter |
| Power Capacity | PV-S-21OC    | Generic 1kWh Li-Ion | Leon 25 |
|                | 1kW          | 1kWh          | 25kW     |
| Unit price (yuan) | 3000        | 600           | 600      |
| Maintenance cost (yuan/year) | 10          | 10            | 0        |
| Replacement cost (yuan)       | 3000        | 600           | 600      |
| Years of use                | 15-25       | 15            | 15       |
4. Operation result

4.1 Optimize simulation results
The optimization simulation results are shown in Figure 3. The most preferred solution is to use only photovoltaics and inverters. The net present value (NPV) of the total input is 186,036 yuan. The sub-optimal scheme is photovoltaic, battery and inverter. The net present value (NPV) of the total input is 197,886 yuan. At this time, the unit electricity cost is 0.165 yuan / kWh. In order to meet the user's needs, the minimum number of series connected batteries is set to 19 when designing parameters, which means that the storage capacity of the battery is also increased to 19 kWh. In this case where the merchant's night-time maximum load demand is 10.8 kWh/day, excessive storage of the battery will result in an increase in initial cost.

We take the time series detailed analysis chart in the optimal solution and draw it out on the day of the peak period, as shown in Figure 4. The yellow line is the output power of the photovoltaic panel. The red is the electricity purchased from the grid. And the black one is the operating power of the inverter. It is worth noting that the peak value of the sales volume represented by the blue line in the figure is 12 kWh at 12 noon, indicating the existence of abandonment. If the government can introduce corresponding policies, it will make more rational use of solar energy resources and energy storage systems, and reduce the number of working hours of thermal power plants.
4.2 Sensitivity analysis

This paper analyses the price of PV equipment and the grid price. The life of the photovoltaic panels is set to two extreme values, 15 years and 25 years, to expand the difference between the optimization results. Assuming that the commercial electricity price (less than 1 kV) in Hainan Province does not distinguish the peak time valley, the price of commercial electricity valley below 35 kV is 0.33 yuan/kWh [9], and the grid price of the grid in the model is set to 0.35 yuan/kWh.

Table 3. Sensitivity analysis data.

|                        | Photovoltaic panel | Photovoltaic panel |
|------------------------|--------------------|--------------------|
| 15 years of use        | 195833 yuan        | 157243 yuan        |
| 25 years of use        | 190628 yuan        | 154456 yuan        |

From Table 3 we can see that the PV service life has a significant effect on the cost reduction. When the service life of photovoltaic equipment is the same, the peak-to-valley electricity price system is not sensitive to the reduction of merchant costs. Taking the life of photovoltaic panels for 25 years as an example, when the price of peak and valley electricity is not divided, the installation capacity of photovoltaic panels is 37kW. When the peak-to-valley electricity price is implemented, the installation capacity is 27kW. Although in terms of economic cost, the incentive effect for users is not as significant as increasing the service life of photovoltaic panels, the scheme saves the area of installing photovoltaic panels. On the other hand, the effect of peak-filling is more significant.

5. Conclusion

This paper is based on the typical optical storage microgrid system model. To meet the basic power load premise, the paper makes the optimal capacity configuration of the microgrid system. According to the operating characteristics and cost of photovoltaics and batteries, this paper simulates an optimal configuration strategy with the minimum cost of investment, operating costs and maintaining the
reliability of power supply. Due to the high cost of energy storage devices at this stage, the economic benefits of PV microgrids are not obvious. As the energy storage costs are gradually reduced or the energy storage subsidy policy is further driven, the commercial investment potential of PV microgrids will be further enhanced.

In the aspect of urbanization, we should make great use of the advantages of urban high-rise building floors, organically combine solar energy utilization with urban construction, reserve solar energy pipelines, and uniform solar installations on the roof to make public lighting. In the rural area, the use of solar water heaters is strongly advocated and low-cost use can be exchanged for many years. In addition, some urban communities and rural farmers can get further subsidies for the installation of solar energy devices when using solar energy. In this way, the development and utilization of solar energy in Hainan Province can obtain the further impetus.

References
[1] Wang C., Li P..(2010)Development and Challenges of Distributed Generation, Microgrid and Smart Distribution Network. Electric Power System and Automation, 34(2): 10-15.
[2] Wang L., Li P., Li X., et al. (2010)Micropower Modeling and Its Application in Microgrid Simulation. Electric Power System and Automation, 22(3): 32-38.
[3] Polaris Power Network.(2017) Hainan Province's “13th Five-Year Plan” Energy Development Plan: Moderately Develop Gas Power and Gradually Optimize Coal Power Structure. http://news.bjx.com.cn/html/20170421/821448.shtml
[4] Lasseter R, Akhil A, Marnay C. (2002)Integration of distributed energy resources: the CERTS microgrid concept . Consortium for Electric Reliability Technology Solutions White Paper.
[5] Carta J A, Ramirez P. (2007)Analysis of two-component mixture weibull statistics for estimation of wind speed distributions. Renewable Energy, 32(3): 518-531.
[6] Gong S., Wei H.. (2014)Microgrid planning and optimization based on HOMER software.In: China University of Higher Education Power System and Automation Professional Academic Conference.Tianjin.
[7] PAINULY J P. (2001)Barriers to renewable energy penetration; aframework for analysis. Renewable energy, 24( 1): 73-89.
[8] Baidu Encyclopedia. (2018) Hainan Province Climate. https://baike.baidu.com/item/%E6%B5%B7%E5%8D%97/13346?fr=kg_qa#3_2
[9] Hainan Province.(2019) Hainan Province Power Grid Sales Price List. http://plan.hainan.gov.cn/sfgw/jggb/201811/8a6f50dfbe094cb3a2d3c824bc4e482a.shtml