Energy Management Optimization Strategy Based on Smart Grid Energy Storage System

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Abstract: With the rapid development of technologies such as distributed generation, demand response, energy storage, power electronics, and charging vehicles, smart grids will integrate power flow, information flow, and business flow, possessing high safety, efficiency, strong reliability, strong self-healing ability, and strong robustness. The demand for electricity in various regions is constantly increasing, and power grid regulation work is becoming increasingly important. Automation and intelligent technologies have been widely applied in power grid regulation. The smart grid has an impact on information and communication technology (ICT), which can automatically aggregate and operate instrument data, thereby improving availability, robustness, economic efficiency, and sustainability. As an extension of the smart grid on the household user side, the home energy management system is an indispensable part of optimizing the electricity scheduling of the home microgrid. The home energy management system is based on the smart grid and integrates the management of all household power equipment, which helps to improve the utilization rate of clean energy and help users save electricity bills; It can also optimize the configuration of household loads and improve the stability of the power grid. This article studies the optimization of energy management in smart grid energy storage systems.

1. Introduction

With the progress of society and the development of technology, the demand for electricity in China has sharply increased, and traditional energy used for power generation is becoming increasingly scarce [1]. With the maturity of new energy generation and demand response technology, traditional power networks are facing challenges such as reduced reliability, intermittent system enhancement, energy flow congestion, and increased complexity of energy management [2].

The traditional power grid provides power to the user's demand side through centralized large-scale generator sets, lacking facilities for real-time information exchange between various links. It can no longer meet the needs of improving power production, distribution, and transmission efficiency in the new era context [3]. In today's era of vigorously promoting sustainable development, the demand for clean, safe, high-quality, friendly, and multi energy complementary power generation is a key issue that the power grid needs to solve. The smart grid is a highly integrated power system with information technology and physical power grids, and the regulation of power production and distribution is an important aspect of the smart grid [4]. With the development of smart grids and the widespread use of renewable energy such as photovoltaics, the use of Home Energy Management Systems (HEMS) has made household users more rational in their electricity usage, and the efficiency of their electricity consumption has been effectively improved [5]. The large-scale promotion of smart grids can greatly enhance the grid's ability to accept renewable energy, achieve large-scale resource allocation, and meet the diverse electricity needs of customers. As an important component of the smart grid and energy internet, energy storage systems can significantly improve the consumption level of renewable energy in the power system, reduce the impact of new energy grid connection on the power grid, and have become one of the key technologies to promote the replacement of main energy from fossil energy to clean energy. Through the scheduling of the home energy management system, users can reasonably and

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effectively control controllable electrical equipment and respond to changes in electricity prices, thereby coordinating the time period during which electrical equipment should operate and work [6]. This not only plays a role in peak shaving and valley filling, but also significantly reduces users' electricity costs.

From the current situation in China, most systems do not have the authority to directly adjust the power of the load. Moreover, in the absence of relevant data interface standards for most household appliances, it is difficult for energy management systems to exchange such information. Therefore, it is difficult to directly control adjustable loads through the system, and most loads still rely on external devices for control and monitoring. Big data has been widely applied in the smart grid industry, and the business data of its system has shifted from a single application data to a massive amount of interconnected data and forms, which is the development trend of smart grid regulation technology support systems. Monitoring big data is a branch of power big data, which can monitor the operation situation of the power grid in real-time through the operation and management of power grid big data scheduling, and actively perceive data resources [7].

2. The Current Situation and Problems of Energy Management in Smart Homes

2.1. Current Situation

The home energy management system can encourage residents to actively participate in electricity management, improve power supply safety and energy utilization efficiency, and play a key role in promoting energy conservation and emission reduction, and reducing environmental pollution [8]. Table 1 lists some of the new features of the smart grid.

Table 1 New features of smart grid

New features	Characteristic
Demand response	Users actively participate in the energy management system of the power grid
New energy power generation	Clean energy generation such as wind power is connected to the power grid
Microgrids	Independent networking of small areas and other areas
Energy storage	Storage and compensation of electric energy in the power grid
Electric vehicle	Having dual characteristics of energy storage and power generation
Phasor measurement unit	Real time measurement of the operating status of the power grid
Controllable and communicable Equipment	Integration of smart meters and other devices

Energy management in smart grids is achieved by collaborating with various controllable and communicable units of the grid to maximize energy efficiency and ensure the safe, stable, reliable, and efficient operation of the entire grid. Energy management can be divided into multiple issues based on different goals, time scales, etc. The household energy management system has been connected to the household side distributed power generation system, changing the traditional power supply method. Currently, there are three main control methods for intelligent home energy management: mixed integer linear programming (MILP), continuous relaxation (CR), and fuzzy logic controller (FLC). Energy users can receive the required energy from the nearest energy supplier to request residual energy. By assigning high priority from users to the nearest provider, the best energy is transmitted to energy users. As the proportion of new energy generation in the total power generation of the power grid increases year by year, the capacity of energy storage systems that need to be configured in the power grid is also increasing [9].

2.2. Problems

With the construction and development of intelligent substations, the amount of monitoring information is increasing, and real-time analysis of alarm business volume is also increasing. The traditional artificial power grid operation, monitoring, and analysis can no longer meet the requirements of integrated operation and coordinated control of the increasingly developing smart grid. In order to obtain accurate status information of the power grid in real-time, smart grid measurement equipment will continue to increase, leading to a sharp increase in the amount of data that the control center needs to collect. However, communication resources are limited, resulting in increased data transmission delay and high communication transmission costs. Traditional centralized control methods have poor scalability and cannot meet the real-time and accuracy requirements of the smart grid [10].

At present, many regions in China are unable to effectively monitor and analyze relevant data, and their control of external business data such as transmission lines, marketing, meteorology, and substation panoramic data is not comprehensive enough. The high level of informatization provides vulnerability space for malicious attackers, and many existing distributed energy management protocols do not consider the impact of potential attacks; Distributed algorithms do not consider communication resource constraints; Lack of analysis on potential privacy breaches in distributed energy management. The existing power grid regulation technology support system does not yet have comprehensive analysis capabilities for big data, and cannot effectively store unstructured data, which cannot effectively support individual businesses and achieve global data collection and sharing. The operation of any power grid will encounter challenges and risks, and to some extent, it will also reveal certain faults. When faults occur, the most prominent problem is power outage, which brings more diversified troubles to the scheduling of smart grids. The particularity of the consumer audience being concentrated in high-income groups has led to a slow promotion of product smart homes, and the majority of salaried consumers can only be deterred, resulting in slow development of the entire industry.

3. Intelligent Home Energy Control Strategy

3.1. Based on fuzzy control

The good robustness of fuzzy control can effectively overcome random noise in actual hardware, as it does not require additional predictive data input and has strong real-time performance. The main process of fuzzy control is shown in Figure 1.

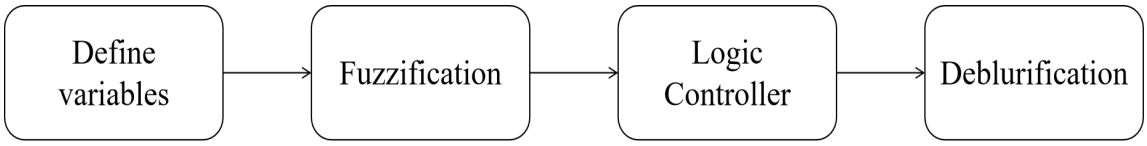

Figure 1 Fuzzy control process

The intelligent home energy management system needs to be an autonomous system that can achieve self-control, protection, and management. Therefore, in addition to primary devices such as load, energy storage, and power supply, a complete system also includes secondary devices composed of monitoring, protection devices, communication lines, and control systems. In an intelligent home energy management system, energy flow exchange is mainly concentrated between distributed power sources, external power grids, household loads, and household energy storage. In terms of specific functional implementation, combined with the actual operation status of the power grid, provide visual information of the current power supply equipment and power supply channels to assist in completing the analysis of the power supply scope; Provide the current network architecture or operating cross-section of the power grid at any time, support simulation of equipment voltage loss and fault conditions, and integrate information such as fault loss load, substation and user number to assess the level of accident events. Provide comprehensive and flexible ways to obtain information to the smart grid regulation support system, in order to improve

the intelligent push capability of user reservation information and important events. Carry out blind corner prevention, control and management for the power grid to meet the needs of real-time monitoring, timely capture current abnormal situations, or identify potential risks and hidden dangers. Once problems are found, they should be immediately pre checked or reported.

3.2. Promoting Technological Development

Relevant R&D and production enterprises should further promote communication at the industry technical level, product integration, and cost control. For different consumer groups, smart home products should be divided into two different positioning levels: low-end and high-end, fully considering the actual needs and affordability of Chinese consumers at all levels. Enterprises need to build an EMS energy management system to accurately analyze the status of cables. The positioning function of this system is extremely prominent, which can improve the level of data calculation and scientifically arrange the power transmission plan and schedule. Build a global communication platform for the smart home appliance industry to establish a complete set of intelligent building and smart home standard systems, create a smart home technology verification platform and comprehensive service platform based on the Internet of Things, achieve interoperability of different brand products, and promote the development of the industry towards scale and industrialization.

Although the operation of the smart grid dispatch and control system is supported by technology, it still cannot be completely separated from human subjects. Therefore, power companies should also have a strong sense of consciousness and foresight, and provide targeted training and guidance based on the talent gap of the power grid itself. The government should continue to introduce corresponding policies to promote the popularization of household energy management systems and strengthen education on household energy management awareness among the public. Electric power enterprises should increase the introduction of composite talents, guide talents to master necessary safety knowledge, and enhance their sense of safety responsibility and mission.

4. Conclusions

Energy management provides effective solutions for smart grid power generation scheduling and responsive demand, thereby providing basic guarantees for efficient, reliable, and stable operation of the power grid. Therefore, energy management is one of the fundamental and important issues in smart grids. Currently, home energy management is not yet well-known to the public in China, and there are few well-known companies engaged in this field in China. Faced with the trend, China should strengthen technological research, reduce the implementation cost of household energy management, and improve the feasibility of system operation; At the same time, more promotion policies will be introduced to encourage relevant enterprises to enter this field. Household electricity consumption is an important component of China's electricity consumption, and its proportion will continue to increase in the future. Intelligent management of it will receive objective economic and social benefits. With the continuous increase in electricity demand, the maturity of new energy generation technology, and the increasing demand for efficiency and low cost, smart grid technology will greatly improve people's lifestyles and production methods. Home energy management systems can effectively assist power consumers in scientifically planning their electricity usage, preventing potential safety hazards, and promoting home energy management systems will be a win-win situation. The smart grid regulation technology support system applies big data analysis technology, constructs a business big data analysis mode, meets the practical application of various analysis businesses, and achieves the stable and large-scale development of the smart grid. With the increasing demand for smart homes, the development prospects of the home energy management market will be even broader.

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