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Friendly Interaction between Urban Users and Power Grid Supply-demand

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Abstract. Friendly interaction between urban users and power grid supply-demand is designed to adequately integrate user-end air conditioners, water heaters, stored energy, Distributed power and electric vehicles, to encourage users to change their energy usage habits by virtue of the two-way interaction mode between users and power grid, and to attain the goal of reducing the overall energy consumption of users and the peak and off-peak difference of power grid. The information interaction between users and power grid, the optimization allocation and intelligent management of Distributed power and electric vehicles, as well as the optimizing control and efficient utilization of electric power can be realized by gathering user-end information on power consumption via the family intelligent energy gateway, using Internet-based power multi-mode communication technology and adapting interface technology and then relying on the friendly interaction system between urban users and the power grid supply-demand.

1. Introduction

With the in-depth development of economic construction in China, the energy consumption manner developed by users becomes increasingly diversified, and users' electricity demand is on the increase as well. The swift growth of nonproductive loads (e.g. air conditioner) has given rise to the overlarge comprehensive energy consumption in different regions and the insufficient power supply capacity, which allows the load peak and off-peak difference in power grid to expand steadily [1]. As the traditionally well-organized power utility means cannot meet the current electricity demand, a solution is imperative to alter the critical energy supply and demand, to relieve the overlarge comprehensive energy consumption in different regions and the expanded load peak and off-peak difference, as well as to cope with the pressure on power grid.

In order to lower nonproductive loads, the author suggests adjusting the energy usage habits of diversified users by making use of market competition mechanism, and encouraging the users to give positive response to the power grid control instructions through the two-way information flow interactions between power grid and user-end families energy network. With the achievement of friendly two-way interaction between user-end and power grid-end, the balance of power supply and demand can be attained in a proper way [2].

In the paper, the author will conduct the study based on the methods to realize a friendly interaction between urban users and power grid supply-demand. Huanjinjihu District in Suzhou City and Wujin



District in Changzhou, Jiangsu Province are selected to perform the demonstration pilots of interactive service. The demonstration pilots are used to verify the energy interconnection and coordinating complementation based on the friendly two-way interaction proposed in the paper, and to provide the friendly interaction services between users and power grid supply-demand with mature and applicative friendly two-way interaction mode and methods by relying on the friendly interaction system between urban users and power grid supply-demand.

2. Friendly interaction system between urban users and power grid supply-demand

Based on the service platform of friendly interaction between urban users and power grid supply-demand, the friendly interaction system between urban users and power grid supply-demand adopts Internet-based power multi-mode communication technology and adapting interface technology to transmit the information from user-end and power grid-end and to coordinate various user-end resources. As the top-level structure, the friendly interaction system between urban users and power grid supply-demand can be used to optimize the energy interaction manners from different types of users. The traditional interaction mode featured with passive acceptance is replaced by a new two-way interaction mode so as to achieve the new energy interaction system centering on the friendly interaction system between urban users and power grid supply-demand.

2.1. Framework of interaction system

Friendly interaction system between urban users and power grid supply-demand can be divided into main station layer, network layer, slave station layer, perceptual measurement layer and device layer. Framework of interaction system is as follows:

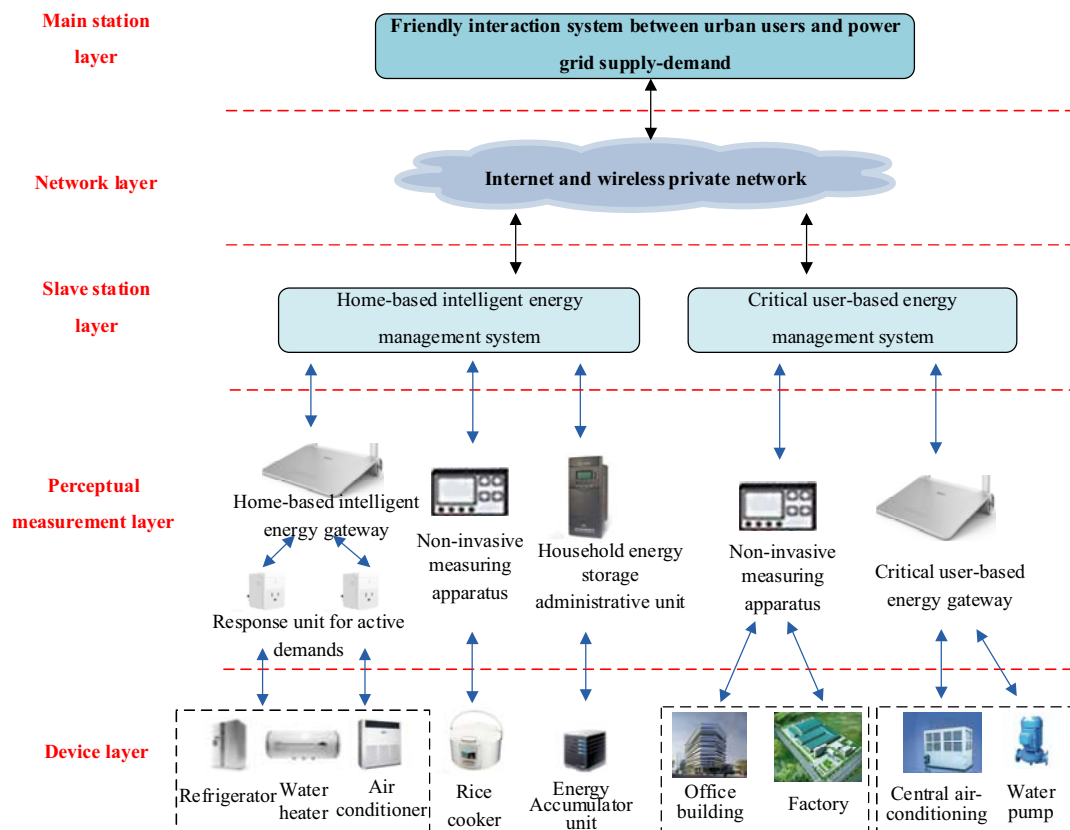


Figure 1. Framework of interaction system.

Main station layer: The data will arrive at the main station layer from bottom to top, and undergo the decision analysis from the main station layer, and then transmit control commands to the device layer.

Network layer: Data transmission will be conducted through the Internet or wireless private network.

Slave station layer: The energy management system at slave station layer will analyze the energy efficiency and energy consumption and transmit the analysis results to main station layer.

Perceptual measurement layer: The user-end will collect information from device layer by virtue of intelligent energy gateway or non-invasive measuring apparatus.

Device layer: Device layer consists of various user-end resources such as homes, communities and critical users.

2.2. Core unit

Core unit involved in the friendly interaction between user-end and power grid supply-demand includes the home user-based response unit for active demands, home-based intelligent energy gateway and household distributed energy storage management unit.

2.2.1. Home user-based response unit for active demands. Being connected with the electric equipment, the home user-based response unit for active demands can actively respond to the system with the regulatory capacity of electric equipment by perceiving the frequency/voltage change of electric system, as well as the electrovalence drive signals. The home user-based response unit for active demands is featured with demand response and automatic control. The electric equipment can be controlled locally or remotely by connecting the home user-based response unit for active demands with users' APP.

2.2.2. Home-based intelligent energy gateway. As the bridge to link the home network of information with the external power network, the home-based intelligent energy gateway possesses the control function with no less than 8 circuits. It can help to realize the optimal control of energy, and the intelligent management and visual energy consumption of energy storage and Distributed power by means of gathering data from user-end, uploading to the system and receiving the commands from system [3].

2.2.3. Household distributed energy storage management unit. Household distributed energy storage management unit solves the problems occurred during the large capacity discharge of traditional energy storage system, such as decreasing of available capacity, terrible cruising ability and low conversion efficiency. With the help of household distributed energy storage management unit, the device rate of waste will greatly decrease, and the energy conversion efficiency is increased to 98%. Besides, household distributed energy storage management unit can accept the centralized control or self-adaptation control from home-based intelligent energy gateway, which is an indispensable part during the interaction process [4].

3. Functions of friendly interaction system between urban users and power grid supply-demand

The friendly interaction system between urban users and power grid supply-demand centering on power grid and users not only achieves the coordination of various user-end resources (e.g. charging pile of electric vehicle, Distributed power and energy storage system), but attains the friendly two-way interaction between the electricity equipment (e.g. air conditioners, water heaters and refrigerators) at user-end and the power grid.

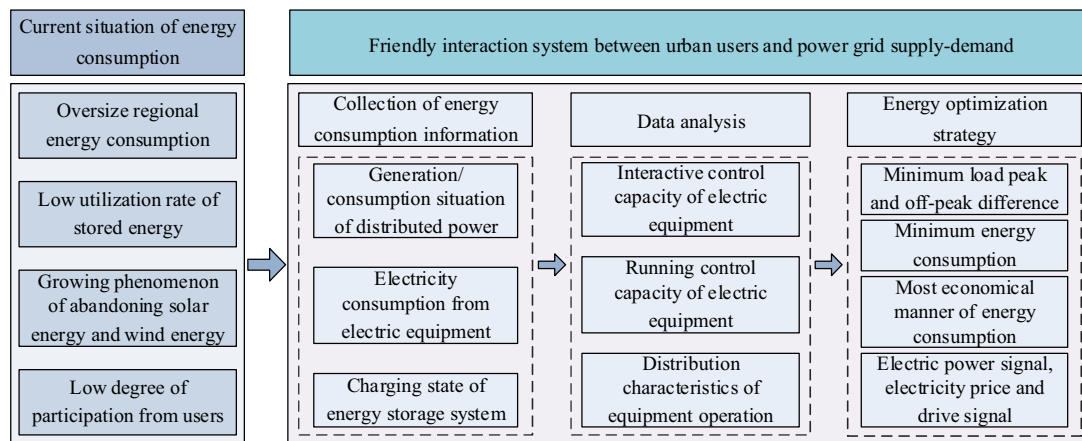


Figure 2. Functional architecture.

Based on intelligent energy gateway, non-invasive measuring apparatus and monitoring equipment, the friendly interaction system between urban users and power grid supply-demand can acquire various kinds of information on resource utilization, including generation/ consumption situation of distributed power, electricity consumption from various electric devices, charging state of energy storage system, as well as the correlation between output voltage and state of charge. The intelligent energy management system shall be used to analyze the energy consumption and energy efficiency from user-end, and attain the interactive control capacity and running control capacity of user-end electric equipment at different energy links, as well as the spatial and temporal distribution characteristics of energy supply, energy consumption and energy storage (reserve of electricity/ice/heat). After that, the friendly interaction system between urban users and power grid supply-demand can formulate the corresponding response strategy with minimum load peak and off-peak difference, minimum energy consumption and most economical manner of energy consumption used as the aggregative indicator. Based on the electric power signal, electricity price and drive signal, the energy optimization strategy will be developed aiming at largest response capacity for peak shaving, maximum absorption for distributed photovoltaic power generation, minimum number of energy storage system charge-discharge and optimal economical efficiency of energy consumption. The energy optimization strategy will be sent to the user-end APP and provide users with suggestions on energy utilization [5].

The electric power signal, electricity price signal and information on electrical equipment shall be seized timely at the response unit for active demands connecting the user-end to the intelligent energy gateway, which can upload the controllable information on electrical equipment to the friendly interaction system between urban users and power grid supply-demand via the intelligent energy gateway. After a comprehensive analysis, the system will obtain the optimal regulatory actions of electrical equipment, and the analysis results will be sent to the user-end APP so that users can control over the electrical equipment properly.

4. Friendly interaction between urban users and power grid supply-demand

According to the power consumption characteristics and natures from different users, the friendly interaction system between urban users and power grid supply-demand is divided into large-scale interactional family, critical-user energy management, large-scale intelligent community and critical-user non-productive loads.

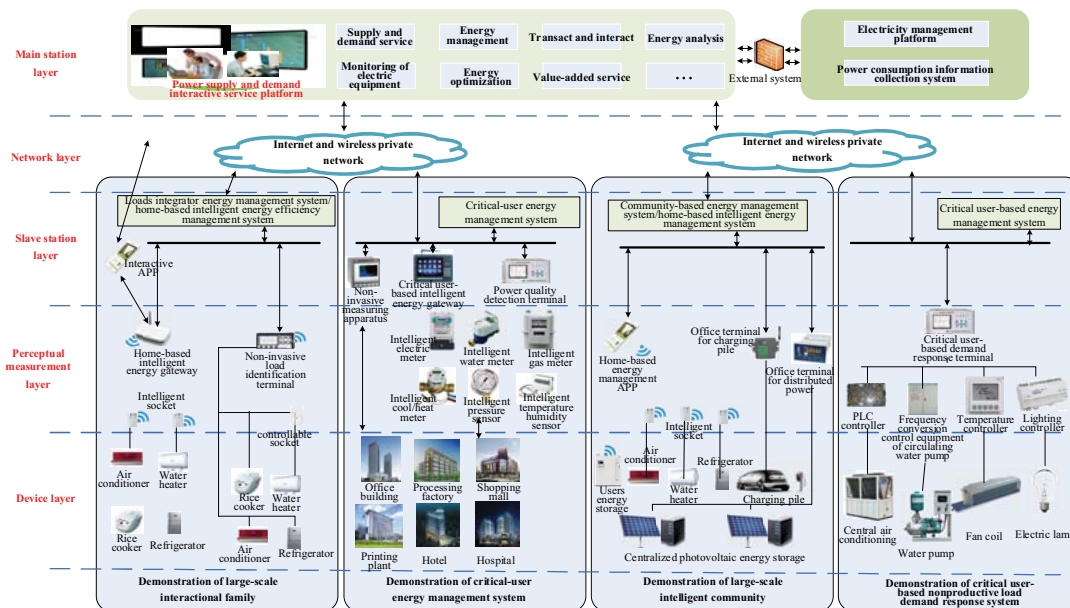


Figure 3. Forms of friendly interaction.

Large-scale interactive home: The electricity consumption information on typical loads such as household energy storage system, refrigerators, household air conditioner and water heaters shall be collected through the installation of home-based intelligent energy gateways for homes achieving the agreements. Based on the interactive control capacity and running control capacity of user-end electric equipment at different energy links, as well as the spatial and temporal distribution characteristics of energy supply, energy consumption and energy storage (reserve of electricity/ice/heat), the system, in consideration of the influence from electricity price, will show users the energy consumption and energy efficiency information of electrical equipment, the controllable capacity of adjustable electrical equipment (including energy storage system charge-discharge), the estimated electric charge saved after regulation and the expected comfort of users at various regulation phases via APP. The users are encouraged to control over the loads in an active manner, which achieve the two-way interaction between user-end and the power grid-end.

Critical user-based energy management: The intelligent electric meter, intelligent water meter and intelligent gas meter shall be switched in from the user-end. The system collects power consumption information of electric equipment via critical user-based intelligent energy gateway, non-invasive measuring apparatus and power quality detection terminal, and then uploads the information to the critical user-based energy management system. After completing the analysis, the system will assign energy-saving instructions to users who can choose to execute it or not, which achieves the goal of lowering energy consumption of critical users.

Large-scale intelligent community: The intelligent community is designed from the perspective of energy flow and information flow, and achieves optimal energy distribution by relying on information flows. The system will conduct a comprehensive analysis of the generation/consumption situation of distributed power, charging state of energy storage system and the load peak and off-peak difference, and then formulate a resource optimal allocation scheme with the goal of minimum load peak and off-peak difference and lowest energy consumption. The reasonable deployment of resources and resources coordination within the community can be realized by proper regulation on energy storage system/electric vehicle charge and discharge, self-contained absorption of distributed power supply and power grid connection, etc.

Critical user-based nonproductive load: In view of the unproductive load from critical users, the system can get hold of the power grid signal, electricity price signal and users' loads information (e.g. central air-conditioning, water pump, fan and electric lamp, etc.) via the critical user-based demand

response terminal, and upload the information on controllable equipment to the critical user-based energy management system. Based on the full consideration of energy consumption pressure on power grid and the load peak and off-peak difference, the system will analyze the optimal control results for the electric equipment. It is the user who shall control over the electric equipment. Only in this way can the users' loads be controlled flexibly without damaging users' economic benefits.

5. Conclusion

In view of the traditionally rigid and passive interaction mode, the shortage of interactive potentials, the imbalance between energy supply and demand, as well as the oversize comprehensive energy consumption, the author develops a new two-way interaction mode between users and power grid, and focuses on finding out the implement methods of new interaction mode. The friendly interaction system between urban users and power grid supply-demand is used to realize the information interaction between users and power grid, to accomplish optimal configuration and intelligent management of various user-end resources, to encourage the users to change their habits of energy utilization, to lower the comprehensive energy consumption and to shorten the load peak and off-peak difference in power network.

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