Research on Energy Efficiency Optimization of Energy Internet Data Center Based on Intelligent Energy Technology

Yu Cao¹, Han-yong Hao²

¹ Information System Integration Company, NARI Group Corporation, Nanjing, Peoples Republic of China.
² STATE GRID Corporation of China, Beijing, Peoples Republic of China.

Abstract: With the extensive and in-depth view of the overall situation of energy, energy as an important material basis affects the development and progress of social economy. Through the research on the connotation of energy internet, the development status of distributed generation and the business model of distributed generation, the value sources of distributed generation in energy Internet system are analyzed. The smart energy technology consists of three parts: the energy management platform, the communication system, and the terminal. The characteristics of low-carbonization, flexibility and energy Internet of regional distributed energy systems under the development of energy Internet were analyzed. Research shows that the interaction behavior of multiple subjects in the energy Internet can not only predict the system equilibrium state in advance, but also provide effective feedback for the optimization and improvement of the system operation mechanism.

1. INTRODUCTIONS

As an important material basis, energy is related to whether the economy and society can move forward quickly and steadily. Taking a new round of energy revolution as a development opportunity and establishing an advanced energy supply system with the goal of safety, reliability, economy, efficiency and clean environment has become a common development goal all over the world. The use of Internet technology will enable non-grid multi-energy collaboration and high-energy-consuming industries to achieve intelligent and deep integration, and form smart energy through big data cloud computing. The core is to establish a global industrial energy Internet system through smart energy, thus promoting China to lead the world to reshape the economic structure. Using Internet technology to realize real-time flow of energy flow and information flow, a new energy utilization system with highly coupled energy supply, transmission network, energy technology and information technology [4]. The main control task is to realize the supply-side and demand-side management at different time scales, and describes in detail the black-start of islanding mode, the planning of infrastructure upgrading and transformation of regional network, and the automatic configuration of new equipment or subsystems. For electric power network including new energy and fossil energy, thermal network [5] and dynamic traffic [6]. The integration and optimization of energy transmission [7-8] network and data network is the inevitable way to realize the sustainable development of energy in the world. Energy and information fusion [9] is an effective way to solve the energy crisis and environmental crisis [10].

In this article, we propose a smart energy technology, which is a technology for energy efficiency optimization research in energy Internet data centers.
2. MATERIALS AND METHODS

The information layer of energy Internet needs to build a communication information system covering all areas and fields of urban energy, which is the wisdom support of energy internet. Turn high energy consumption industry into high efficiency industry. Including smart meter, carbon emission, intelligent operation and maintenance, energy consumption monitoring, energy efficiency management, demand response, user-side appliances, distributed charging piles and other network service modules and control modules coordinate cooperation. The global dynamic optimization of network bandwidth resources is realized through traffic monitoring, flow table delivery, link discovery, and network topology.

There are not only differences in reserves but also differences in characteristics among different energy resources, such as time, space, technology level, storage, pollutant emission, etc. If the merits of one energy source can just make up for the shortcomings of another energy source, then they have the possibility of complementary utilization. The comparison of economics and emissions of various types of energy generation in China is shown in Table 1.

| Type             | CO2 emissions | Influence factor                      |
|------------------|---------------|---------------------------------------|
| High carbon      |               |                                       |
| Coal             | 932           | Combustion efficiency and reserves     |
| Natural gas      | 567           |                                       |
| Crude oil        | 806           |                                       |
| Low Carbon       |               |                                       |
| Geothermal energy| 92            | Temperature and Depth                 |
| Solar photovoltaic| 0            | Geographical location, weather        |
| Solar Thermoelectricity| 0    | Geographical location, weather        |
| Wind energy      | 0             | Topography, Weather                   |
| Biomass energy   | 0             | Growth of trees and crops             |

With the change of energy structure, the new energy industry has developed rapidly. The high proportion of distributed energy penetration and the large-scale access of electric vehicles make the grid structure more complex and flexible, which has the characteristics of large uncertainty, strong non-linearity and complex coupling relationship. In the user side of energy internet, according to business modeling, data acquisition function is an important part of it. In the field of new energy, the Internet of Things (IOT) can provide data links for distributed generation systems, decentralized off-grid micro-new energy systems, such as wind-solar complementary street lamps, wind-solar complementary monitoring and control, photovoltaic water pumping and so on, which are almost unrestricted by geographical boundaries. Coordinating dynamic pricing, supply strategy and storage management of power supply micro-units based on demand side analysis will become the basic functions of energy internet. The framework of the Energy Internet is shown in Figure 1. Distributed network business integration will inevitably require efficient data acquisition technology as a support. The data collected by the users contained in an area is collected in the regional control center and then transmitted to the remote server main station to prepare for subsequent processing of the analysis data.
The energy industry's energy Internet has subverted the traditional energy development model, achieved multi-energy synergy development, and can exert the comparative advantages of various energy sources; it has subverted the global traditional power grid structure and unconditionally obeys the electricity side from the traditional power generation side. In the qualitative comprehensive analysis, the reliability of the road network is related to whether the electric vehicle can successfully reach the intended destination, which will affect the vehicle properties of the electric vehicle. The commercial value of microgrid in the energy internet, as an independent market subject, participates in the energy internet. The global grid-level communication network framework is shown in Figure 2. However, with the increase of energy Internet traffic, the traffic control, logical network partition and resource utilization of communication network cannot be considered comprehensively. Lack of logical control plane will make the network "unknown" and "uncontrollable". Participate in carbon trading by using green and clean energy; participate in electricity trading as an independent market participant; provide peak shaving and other ancillary services, participate in global energy optimization, and integrate with energy internet.

At the level of energy information management, it can transmit and publish the management data and service information related to electricity price and electricity quantity. The use of energy-based LANs with advanced energy routers as the core device enables energy “in-place production, on-site
transactions, and local use”. Reduce problems such as line loss caused by long-distance transmission, and promote the efficient use of renewable energy and energy. The possible forms of energy routers are shown in Table 2 and Figure 3.

Table 2 Possible forms of energy routers

|                              | Forecast       | Optimization  |
|------------------------------|----------------|--------------|
| Electric energy conversion   | 3.05±0.32      | 2.95±1.73    |
| Fault protection             | 2.96±1.72      | 3.15±0.69    |
| information transfer         | 3.05±0.51      | 2.95±0.81    |
| Demand response              | 2.51±1.62      | 3.18±1.52    |
| Supply and demand balance    | 3.51±0.32      | 1.41±0.91    |

Fig. 3 Possible configuration of energy routers

3. RESULT ANALYSIS AND DISCUSSION
As an important energy network in regional integrated energy system, power grid and heat network play different roles in supply. Generally, electric energy and heat energy are independent in production process. However, the power system and the power system can be connected on the power supply side through the cogeneration unit. Power supply combines with the use of large data and is user-oriented, which reduces the transaction cost of electricity. The new business model of electricity market has been born, the information barrier in traditional energy system has been broken, and the comprehensive energy utilization efficiency has been improved. Traditional energy systems cannot respond quickly to the needs of each user. Under environmental constraints and energy structure reform, distributed energy development may bring higher energy efficiency, and there is an incentive for the role of energy demand side and supply side to exchange under benefit sharing mechanism. The selection of convergence switch is realized by the function of network component. At the same time, the geographical information virtual table is established in the network information base to facilitate control of energy calls between cells. In addition, the access controller and the domain controller cooperate with each other through reliable technology to realize the service and control of the communication network and achieve reasonable utilization of communication resources.

Energy storage technology provides a means for the economic operation under the background of the development of energy internet, as well as improving the possibility of users participating in
energy market transactions. Energy storage is the storage of energy in the form of electricity and heat by physical or chemical means, and is released when useful energy is required. According to the form of energy storage, energy storage technology is divided into mechanical energy storage, electromagnetic energy storage, and chemical energy storage. Several typical electrical energy storage technical parameters are shown in Figure 4.

![Figure 4 Typical technical parameters of electric energy storage](image)

In the regional integrated energy, the electric energy is mainly provided by the conventional thermal power unit, the cogeneration unit and the new energy generator set, and is transmitted through the user side and the V2H system. The specific electric power balance expression is:

\[ I_k (x, y) = |P_k (x, y) - P_{k-1} (x, y)| \]  

(1)

Total number of conventional thermal power units: \( I_k \)
Total number of cogeneration units: \( P_{k-1} \)

Heat energy is mainly supplied by cogeneration units. It is transferred and regulated by user side and energy storage system. The expression of heat power balance in the integrated system is as follows:

\[ D_k (x, y) = |f_{k-1} (x, y) - f_k (x, y)| \]  

(2)

Direct heating part of heat load: \( D_{k(x,y)} \)
Thermal load of the system during the time period: \( F_k \)

Taking each subsystem model as the main constraint condition of the joint scheduling optimization model, wind power is the minimum abandonment wind power in the region, and an integrated scheduling optimization model is established. The energy balance relationship, the objective function is established as follows:

\[ B_k (x, y) = |f_k (x, y) - B (x, y)| \]  

(3)

\[ T_k (x, y) = D_k (x, y) + B_k (x, y) \]  

(4)

Total number of scheduling periods: \( x, y \)
Continuity of optimization process: \( B \)
Energy production cost: \( k \)

Thermoelectric production relationship constraints. The constraint is mainly for the cohesive characteristics of thermal energy and electric energy in the cogeneration unit. Assuming that the
Electrothermal ratio of the cogeneration unit remains unchanged, the specific expression is:

\[ R_i(x, y) = \begin{cases} 1, & \text{if } T_i(x, y) > Th \\ 0, & \text{if } T_i(x, y) \leq Th \end{cases} \]  

\[ (5) \]

Electric heating ratio of cogeneration units: if

The constraint combines the production and storage of energy in the cogeneration unit from the perspective of heat flow. The specific expression is:

\[ \eta^2 = \frac{4e_iU_0}{9eZN_l} \left[ \left(1 + \frac{u(t)}{U_0} \right)^3 + 3\frac{u(t)}{U_0} \right] \]

\[ \pi D^2 Z N_0 \cos \left( \frac{b_0 - a_0 (D_{max}^2 + 1)}{D^2} \right) \]

\[ (6) \]

\[ i(t_0) = \frac{\pi D^2 Z N_0 \cos \left( \frac{b_0 - a_0 (D_{max}^2 + 1)}{D^2} \right)}{4 (a_t + 0)} \]

\[ (7) \]

Output of Cogeneration Unit in Time Period: \( U_0 \)

Operating Interval of Cogeneration Units: \( U(t) \)

Hybrid energy real-time optimization decision-making combined with predictive and reinforcement learning, and energy equipment failure analysis supported by small sample technology will also become the key research direction. At the same time, smart energy technology will focus on how to interact with the dynamic environment and fully consider the timely, stable and safe decision-making requirements of the power system. The construction of smart energy technology takes the multi-dimensional analysis of information and the integration of cross-professional business as two key points to design and develop a series of practical business applications based on panoramic data center and to meet business needs. Considering that the power generation capacity of each energy source is determined at different time periods, the user groups will influence each other and dynamically change when calculating the benefits obtained by different strategies. Therefore, each user can evolve slowly by changing the component value of purchasing strategy vector to ensure that each individual in the group can evolve under the corresponding constraints. Various analog quantities play an important role in the production, operation, condition monitoring, fault diagnosis, maintenance and maintenance of energy power system, and are one of the important data connection fields of the Internet of Things. The control strategy of the network needs only one deployment to take effect. According to the internal network services and control functions, links can be re-designated with better coping strategies. Therefore, it ensures the reliable transmission of user energy data and user demand response at the same time. The energy consumption is further saved. For example, in the combined cooling, heating and power supply system, the primary energy utilization rate is significantly improved due to the cascade utilization of energy. Energy saving is absolute value and energy efficiency ratio is relative value.

4. CONCLUSIONS

In this paper, the energy efficiency optimization of energy Internet data center based on smart energy technology is studied. Energy is an important material basis for promoting social and economic progress. From the current situation and utilization of energy, coal, oil and natural gas are still the most important primary energy sources in the world today. Through the information interconnection between distributed renewable power sources and users, as well as between local energy and power networks, we can make better use of the space-time complementarity of distributed power sources in a wide area and the system regulation potential between energy storage equipment and demand-side controllable resources. In a certain spatial structure, under certain constraints, based on environmental protection, economic and other objectives, system planning analyses the shortcomings of traditional power communication network supporting user energy management according to business modeling. In view of the technical characteristics and advantages, this paper proposes an analysis and simulation experiment based on the communication network architecture to support the user’s energy management delay, security, reliability and security, and verify the adaptability of the architecture.
Through the planning of energy demand, system construction, configuration optimization, and network optimization, the system's capacity, energy, energy, energy storage, and energy-saving processes are implemented, and energy transmission networks, energy information transmission networks, and energy equipment are designed. The Internet of Things, the architecture of the regional energy Internet.

REFERENCES

[1] Jin H, Cheocherngngarn T, Levy D, et al. Joint Host-Network Optimization for Energy-Efficient Data Center Networking. [J]. Alzheimers & Dementia, 2013, 9(4):623-634.

[2] Gu J, Ouyang M, Lu D, et al. Energy efficiency optimization of electric vehicle driven by in-wheel motors[J]. International Journal of Automotive Technology, 2013, 14(5):763-772.

[3] Chong F T, Heck M J R, Ranganathan P, et al. Data Center Energy Efficiency: Improving Energy Efficiency in Data Centers Beyond Technology Scaling[J]. IEEE Design & Test, 2014, 31(1):93-104.

[4] Gu Q, Tang T, Ma F. Energy-Efficient Train Tracking Operation Based on Multiple Optimization Models[J]. IEEE Transactions on Intelligent Transportation Systems, 2016, 17(3):882-892.

[5] Cho J, Kim Y. Improving energy efficiency of dedicated cooling system and its contribution towards meeting an energy-optimized data center[J]. Applied Energy, 2016, 165:967-982.

[6] A. Yayimli and C. Cavdar, “Energy-aware virtual topology reconfiguration under dynamic traffic,” in Proc. 2012 14th Int. Conf. Transparent Opt. Netw., 2012, pp. 1–4.

[7] Kyriakopoulos C A, Papadimitriou G I, Nicopolitidis P, et al. Energy-efficient Lightpath Establishment in Backbone Optical Networks Based on Ant Colony Optimization[J]. Journal of Lightwave Technology, 2016:1-1.

[8] J. Zhanget al., “Energy-efficient traffic grooming in sliceable-transponder-equipped ip-over-elastic optical networks [invited],” J. Opt. Commun. Netw., vol. 7, no. 1, pp. A142–A152, 2015.

[9] S. K. Dey and A. Adhya, “IP-over-WDM network design methodology to improve efficiency in overall expenditure due to cost and energy consumption,” J. Opt. Commun. Netw., vol. 7, no. 6, pp. 563–577, 2015.

[10] T. Liao, K. Socha, M. de Oca, A. Marco, T. Stutzle, and M. Dorigo, “Ant colony optimization for mixed-variable optimization problems,” IEEE Trans. Evol. Comput., vol. 18, no. 4, pp. 503–518, Aug. 2014.