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Research Framework of "Internet plus Dispatchable Loads" Integrated Dispatching Platform

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Abstract. In order to fully tap the regulating potential of dispatchable loads (DLs) and to bring DLs into the normal dispatch and operation of the electric power system, research on the "Internet plus dispatchable loads" integrated dispatching platform is needed to provide access interface for the power grid and customers. In this paper, an overall research framework is demonstrated and the technical scheme of platform implementation is defined.

1. Introduction

For a long time, the potential of demand side to improve power demand-supply relationship and system operation has not been fully excavated, and demand side has not been integrated into the dispatch and operation of the electric power system [1, 2]. Since the 1980s, many countries have been actively promoting the market-oriented reform of power industry, and the concept has been gradually developed of coordinating demand side resources with generation side resources and promoting power demand-supply balance [3]. Diversified interactive modes offered by the market-oriented reform of power industry provide favorable conditions for fully tapping the potential of demand side resources. With the deepening of China's market-oriented reform of power industry, demand side will deeply participate in the dispatch and operation of the electric power system.

In order to fully tap the regulating ability of dispatchable loads of demand side, lots of academic and industrial researches are done. Such researches often come to demand side management (DSM) and demand response (DR). Researches in the USA begin early, and relative policies and regulations in the USA are fairly complete. DSM projects launched in Europe have obtained dramatic effects. In the past few years, China has introduced policies to provide support for realizing DR. Many parts of China have established a variety of electrovalence systems for customers to choose, and businesses are compensated for their voluntary load interruption during the peak power demand time.

In recent years, the spread of electric vehicles has created favorable conditions for implementing the dispatch of DLs, and researches on electric vehicles are launched. Large quantities of electric vehicles being integrated into the power grid will have significant influence on the schematization and operation of the electric power system. Therefore, the vehicle-to-grid concept has been analyzed in recent years [4, 5, 6].

Techniques relative to "Internet Plus" have made great achievements in the field of e-commerce, finance, online-to-offline, travel services and so on, such as cloud computing, big data, Internet of things and mobile Internet. However, the application of "Internet Plus" in dispatching DLs is still in the exploring stage. This leads to the inability to implement automatic DR and to integrate DLs into the power grid.

In this paper, we have made full use of the progress made in the field of Internet technologies, DR and DSM to research on the "Internet Plus Dispatchable Loads" integrated dispatching platform.

2. Principles

In order to fully tap the regulatory potential of DLs and constantly integrate DLs into the dispatch and operation of the electric power system, we need to research on the "Internet Plus Dispatchable

Loads" integrated dispatching platform and provide access interfaces for the power grid and customers. When designing, the following principles should be satisfied.

2.1 No Side Effects.

The establishment of the platform should not disturb the operation of the original electric power system. If data communications and information interchanges between the platform and the electric power system are required, strict isolation and protection mechanism should be established, strict operating specifications should be followed, and thoroughly test should be done.

2.2 Be Extensible.

Take multiple factors into consideration, such as the diversity of DLs and the extensibility of subsequent businesses, the platform should adopt a flexible system architecture so that it can be extensible. For example, a new kind of DL should be able to be automatically added into the platform through quick system configurations.

2.3 Provide Abundant Data Access Interfaces.

The accumulation of loads and the amount of customer power data grow with the operation of the "Internet Plus Dispatchable Loads" integrated dispatching platform. Thus, the platform should provide abundant data access interfaces so that a diversified user interface can be displayed. At the same time, by using big data technologies and data mining algorithms, we can acquire the intrinsic value of the data or do relative scientific researches.

2.4 Be Secure.

The platform should meet the requirements for the secure operation of the electric power system. Meanwhile, both the software and the hardware should meet the safety requirements to ensure the security and stability of the system.

2.5 Be Efficient.

During the operation of the "Internet Plus Dispatchable Loads" integrated dispatching platform, the quantity of data processing expands rapidly resulting from the increase of the amount of integrated DLs and users. Therefore, the platform should be efficient in data processing. In software, an efficient data-processing algorithm should be used and a flexible system architecture should be adopted. In the meantime, the platform hardware should also have rapid expansions.

3. Research Framework

The overall research framework of the "Internet Plus Dispatchable Loads" integrated dispatching platform includes five layers from bottom to top: user terminal layer (UTL), lower communication layer (LCL), central platform layer (CPL), upper communication layer (UCL) and power-grid management layer (PGML). Each layer has its own independent functions which can be separately developed, and the layers communicate to each other by unified access interfaces.

3.1 User Terminal Layer.

UTL completes functions such as the data acquisition of DLs, the transmission of regulatory instructions and the management of user-side visual terminals.

Various kinds of DLs differ in communication protocols. Take this into consideration, each DL is equipped with an advanced measurement and control terminal to complete the data acquisition. The terminal can acquire data from the corresponding DL and control the corresponding DL according to the regulatory instructions received through UTL communication channel.

The user-side visual terminals are aimed to satisfy users' requirements for interactive operations, for example, visual query. There are multiple choices for user-side visual terminals such as PC, Apps and WeChat. Through visual terminals, users are able to visually grasp the state, usage and other information of DLs in real time, and to register and control the DLs individually. The terminals can communicate with the DLs through the Internet, LAN and general interfaces of smart home system.

The platform also provides access interfaces for load aggregators which meet the standards and specially customize visual terminals for these load aggregators.

3.2 Lower Communication Layer.

LCL is mainly responsible for communication between UTL and CPL, consisting of data communication interfaces and communication channels.

With the aid of data communication interfaces, data communication mode can be unified, the differences between DLs and visual terminals can be ignorable and a unified data communication protocol for UTL and CPL can be provided.

Communication channels contain two main types: wired (e.g. optical fiber) and wireless (e.g. GPRS/3G/4G/Wi-Fi).

3.3 Central Platform Layer.

CPL is the core of the "Internet Plus Dispatchable Loads" integrated dispatching platform, including lower firewall, server cluster and upper firewall.

Lower firewall provides a firewall mechanism to ensure security and reliability of network communications between CPL and LCL.

Server cluster is composed of computing servers, communication servers, data servers and extended servers. Computing servers complete the computing tasks of the platform, such as the calculation of control strategy, power flow calculation and load forecasting. Communication servers are responsible for communications between layers. Data servers are responsible for storing data. Extended servers are kept in reserve for the follow-up system expansion.

Upper firewall provides a firewall mechanism to ensure security and reliability of network communications between CPL and UCL.

3.4 Upper Communication Layer.

UCL is mainly responsible for communication between PGML and CPL, consisting of data communication interfaces and communication channels.

In order to communicate with the information platform of the power grid, specialized access interfaces and communication protocols are provided for normalized access to PGML.

Communication channels contain two main types: wired ones including optical fiber, and wireless ones including GPRS, 3G, 4G and Wi-Fi.

3.5 Power-Grid Management Layer.

PGML is made up of an isolation platform and visual terminals.

The isolation platform provides unified data access interfaces for communication between the power grid and external media. This platform is an isolation facility for information security independently researched and developed by State Grid Corporation of China. On the one hand, it isolates the Intranet and the Internet from the network link, which effectively defenses against computer viruses and hacker attacks. On the other hand, it carries out fine-grained safety detection on the data exchanged to identify illegal requests and to prevent access and operations beyond the limits of authority. Though these methods, the isolation platform can secure the application system and data of the power grid.

Visual terminal is a method to communicate with dispatchers. Visual terminals can choose various presentation forms, such as PC, Apps and WeChat. Through visual terminals, dispatchers are able to visually grasp the state, dispatchable ratio and other information of DLs, control DLs and gather feedback. For example, by interacting with the existing geographical information system of the power grid, dispatchers can easily see the situation of DLs in any province or district. For security reasons, communication between visual terminals and the power grid dispatching platform.

4. Summary

In this paper, first, the overall research framework of the "Internet Plus Dispatchable Loads" integrated dispatching platform is demonstrated and the principles to follow are put forward when designing the platform. Then, the five layers covered in the platform (user terminal layer, lower communication layer, central platform layer, upper communication layer and power-grid management layer) and their functions are discussed. For future works, relevant plan of pilot operation, the evaluation and promotion of the pilot and more business models can be deeply

discussed, which provides a roadmap for the implementation of the actual development and promotion of the “Internet Plus Dispatchable Loads” integrated dispatching platform.

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