Implementation of Automatic Demand Response under the Ground of Retail Side Open in China

Yao Wang[1, a], Songsong Chen[2,b], Mingfeng Sun[1,c], Jianyi Zhao[1,d] and Jun Zheng[1,e]

[1] State Grid (Shanghai) Smart Power Grids R&D Investment CO.LTD, Shanghai, China

[2] China Electric Power Research Institute, Beijing, China

[a]369648010@qq.com, [b]chensongsong@epri.sgcc.com, [c]18600365587@126.com, [d]hanwanjiao2007@sina.com, [e]413501559@qq.com

Abstract. The demand response pilot work of China has achieved remarkable results in Jiangsu, Shanghai, etc. However, there still hasn't a unified business process being made, and the participation of diversified market subject such as new electricity retail sales company has intensified the market competition under the background of retail side open. Therefore, without a unified implementation mode the automatic demand response (hereafter referred to as auto-DR) business can't develop in order. Based on the comprehensive analysis of affecting factors, such as electric policy changes, new market subject emerging etc, the influence of the open electricity sale market on auto-DR business main body, operation flow, business mode and other aspects will be discussed; the energy trust, energy saving service and other new auto-DR modes will be researched around the electric vehicle, distributed energy, user-side energy storage and regional integrated energy management; the role and positioning of each entity participating the auto-DR business will be discussed; the auto-DR service architecture will be studied, that accommodate to power sold market gradually being opened. The application and innovation mode of auto-DR will be proposed; the auto-DR business process which is compatible with energy trust and energy saving will be designed, including the business process and relationship of each participant; the auto-DR business architecture will be constructed that is suitable for domestic electricity marketing gradually thorough..

Introduction

March 2015, CPC Central Committee and the State Council promulgated Several Opinions on Further Deepening the Reform of Electric Power System (No. [2015]9), emphasized to develop the power DSM actively, through the use of modern information technology and the implementation of DR, to promote the balance between supply and demand and energy-saving and emission-reduction. April 2015, NDRC and the Finance Ministry promulgated Announcements on Improving the Power Emergency Response Mechanism and Ensure Power DSM Cities Comprehensive Pilot Work (No. [2015]703) and other policy file, emphasizing implementing DR at the peak power demand and tight supply in the summer and winter of 2015, the corresponding reduction in the load included in the temporary reduction in peak power load. The promulgation of the above policy document, laid police foundation for the further development of DSM and provided policy support for widespread implementation of DR service.

The promulgation of Power DSM Cities Comprehensive Pilot, New Electricity Reform and other policy file, provided policy support for DR implementation. Construction of intelligent power

information infrastructure such as electric power service management platform, Smart Park, Intelligent Community and electric data acquisition system systems, laid technology foundation for DR. The increase of new flexible adjustable resources such as user side DER, energy storage and electric vehicle, further enhanced the user side adjustment capability. The way of realizing the DR will change from administrative intervention to market regulation. The implementation mode of DR will change from passive orderly power consumption to automatic DR. The subject of DR implementation will be mainly new electricity company. DR implementing mechanism will newly increase demand side bidding, capacity ancillary services, etc.

Starting in 2014, under the guidance of the NDRC, Shanghai, Jiangsu, Beijing, Foshan and other places started DR pilot, the cumulative peak load reduction has been more than 2200 MW, equivalent to 3 hydro generating units installed capacity of the Three Gorges Power Station. Although DR pilot work has made remarkable achievements, but there is no unified business processes formed. And under the background of power-sold side open, the participating of new electricity company and other diversified market subjects intensified the market competition, the uniform implementation mode is of the urgent need for supporting automatic DR service to develop orderly.

Analysis of domestic and foreign status

Domestic and foreign policy. In foreign countries, affected by the flexible power market transaction mode, the power infrastructure investment limit, the extreme weather threat to the power grid reliability and so on. The United States, Japan and the European countries are making great efforts to develop DR. In 2011, FERC No.745 file ordered grid operators to pay DR suppliers the same as generators. In January 26, 2016, the Supreme Court promulgated Electric Power Demand Side Response Regulation to clearly defined load resources to participate in power market transactions the same as power generation resources. In 2012, METI lead the first domestic implementation of DR empirical service in Yokohama city. In June 2014, the Japanese cabinet meeting agreed the new IT strategy, aimed at completing DR empirical service at the year and striving to promote the popularization in 2016. In 2006, the EU promulgated A European Strategy for Sustainable，Competitive and Secure Energy, the goal of intelligent electricity service is put forward. But because of the different operation rules and technical standards of the regional electricity market, the overall implementation plan of DR has not yet formed.

In China, since 2012, a number of policies was introduced to promote the DR pilot, and DR was included in the national plan for 13th Five-Year. In July 2012, Interim Regulations of Central Finance Incentive Funds Management of Power DSM City Comprehensive Pilot ruled that reward 100 RMB per kilowatt on temporary reduction of peak power load by DR. In March 2015, Several Opinions on Further Deepening the Reform of Electric Power System proposed to develop the power DSM actively, through the use of modern information technology and the implementation of DR, to promote the balance between supply and demand and energy-saving and emission-reduction. And further enhance the level of the balance of supply and demand mainly based on DSM. On March 16, 2016, The 13th Five-Year Plan pointed out adapting to the DER development and the users' diversification requirements, improving interactive response capability of demand side. And build energy internet with the coordinated development and integration of "source-grid-load-storage".

Domestic and foreign DR pilot. In the United States, in 2014, the national DR saved electricity about 1 billion 430 million kWh and saved about 11 million 700 thousand kilowatts of power savings in peak period. In February 6, 2014, affected by the extreme cold weather and natural gas shortages,

CAISO required Pacific Electric Company and other companies to conduct DR, the total reduction of power load reached 800MW. In Japan, in October 2014, KYOCERA Corporation associated with Japan IBM and other companies, conducted 5 months automatic DR empirical test in 25 places including the KYOCERA Yokohama business. In Europe, the British KiwiPower company founded in 2015, could use DR to complete nearly 200 MW electricity distribution of the UK grid in seconds, and the duration could last 1 hour.

In China, the corresponding DR platform, load aggregation system and mobile client, etc. were researched in the pilot work, to support the users' convenient participation. The implementation mode of Jiangsu Province is that led by the government, specific organization and implementation is by the grid company, and the load integration and power user actively participate. DR project types mainly include appointment DR, real-time DR. Appointment DR refers to complete response invitations and confirmation process the day before DR Day, conduct DR at the appointed time in DR Day completing appointed load reduction. Real-time DR refers to the user receive the response instructions, send real-time confirmation of participation and conduct DR. In August 4, 2015, during the DR period from 14:30 to 15:00, the cumulative reduction of peak load was more than 1,800 MW.

Implementation mechanism and mode of DR

Implementation mechanism of DR. DR mechanism is mainly divided into two categories, namely the price DR and incentive DR. According to the different application, the two types can be divided into a variety of realizations.

Price DR. Price DR is that reflect the time difference of the power supply cost by adjusting the electricity price spontaneously or by the market. For example, the price fluctuates with cost or setting sectional price which rough reacts cost fluctuations, let users adjust their consumption behavior according to the price signals, in addition to according to the schedule in time and way. Specifically, the price DR is to reduce the use of electricity at the peak of the higher prices, increase the use of electricity at a low price of the non-peak (make up the electricity cut before) to smooth the load curve, which will transmit the price signal to the end user which reflecting the true cost, enhancing the price response capacity of demand side, and improving the stability of the power system. Power users participating in such projects can directly reduce peak load demand or shift some of the peak load to non-peak hours. In particular, the price DR projects include: 1) Time of Use Pricing (TOU), 2) Critical Peak Pricing (CPP), 3) Real Time Pricing (RTP), etc[1-5].

Incentive DR. Incentive DR directly uses incentive methods to motivate and guide users to participate in load reduction project needed by a variety of systems. Currently incentive DR projects commonly used all over the world include Direct Load Control (DLC), Interruptible Load (IL), Demand Side Bidding (DSB), Emergency Demand Response (EDR) and Capacity/Ancillary Service Program (CASP). Before the concept of DR, the United States has seen DLC and IL as projects as the measures to ensure the reliability of the system. Demand side bidding, emergency DR and CASP appeared late, it has a great advantage in the system's monthly capacity plan, day-ahead market economic dispatch, real-time market economic dispatch and spare service. Compared with the price DR, the incentive DR can be more flexible and convenient to realize the peak load shifting[6-13].

Implementation mode of DR.

Changes in the implementation mode of DR. The current DR, although there is a subsidy, in nature having the nature of the subsidy. Signing the agreement to cut off has the compensation, not

signing the agreement may not be without power. At this stage the main role of DR is to solve the electricity gap, as shown in Fig 1.
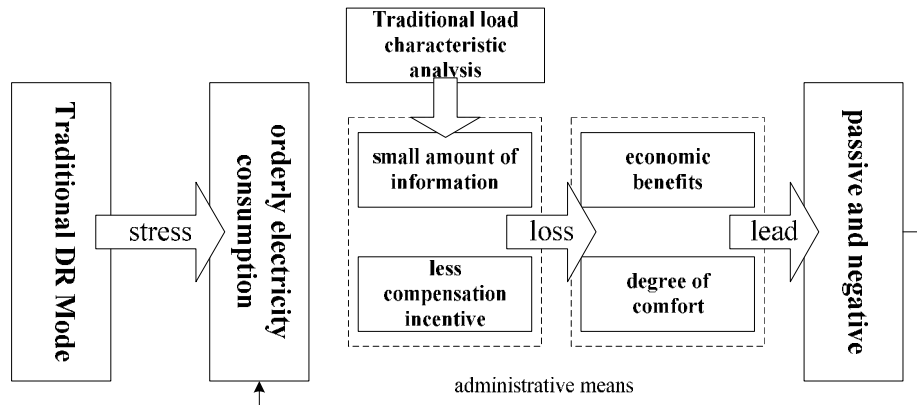

Fig 1 Former implementation mode of DR

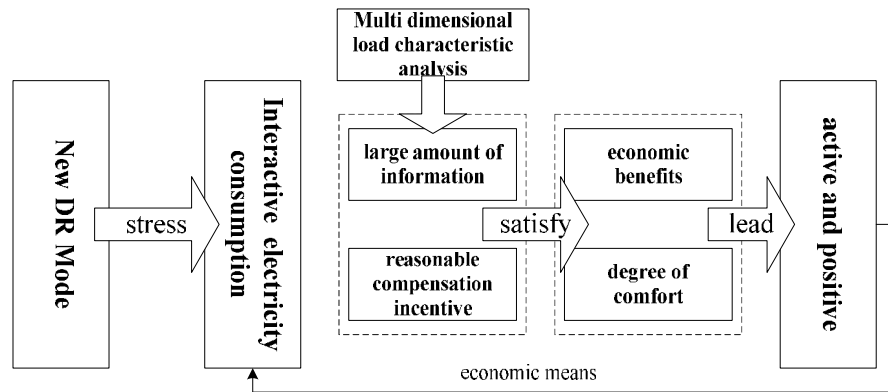After the power-sold side open, DR will provide ancillary service capacity additionally, as shown in Fig 2.

Fig 2 New implementation mode of DR

Architecture of DR implementation mode. The main subject of DR consists of energy aggregators (third party service providers), users and power suppliers. As a power company (generation, transmission and distribution), first of all, provide energy for the users. Users access electricity through energy interface connecting power grid distribution facilities. And users can also provide electrical energy through this energy interface to the grid, which transporting energy from users distributed energy system back to the grid. Grid control center not only operates and controls the grid ensuring the power supply in the field of smart grid, but also negotiates lower energy aggregators to manage the electric power facilities of users, including user energy management system, user load facilities, user storage energy, and distributed energy system, to make a reasonable and safety use of electricity. As the ultimate subject of participating DR, users are dealing with ancillary service and peak averting demand and other power shortage situation by cutting load and let DER participate in the regulation of power grid load as a new type of energy. It is shown in Fig 3.
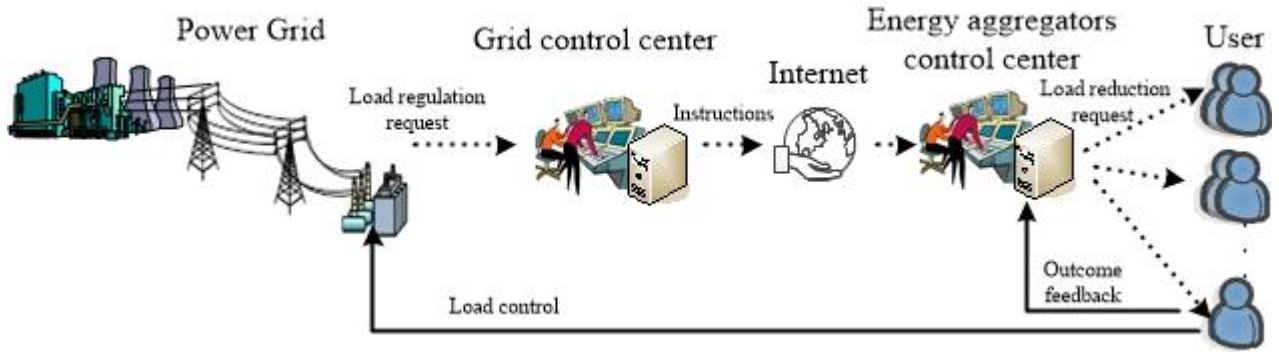
Fig 3 Architecture of DR implementation mode

Architecture of DR service

System architecture. State Electric Power DSM DR Platform is respectively as the DR subsystem of State Power DSM Platform and Provincial Electric Power Service Management Platform, centralized deploying at the national level and provincial level. Install DR terminal and DR load monitoring terminal on the user side, detailed related DR processes are conducted by the provincial DR subsystem. State DR subsystem focuses on information collection and analysis, and provides data mining and auxiliary decision-making functions. System diagram is shown in Fig 4.
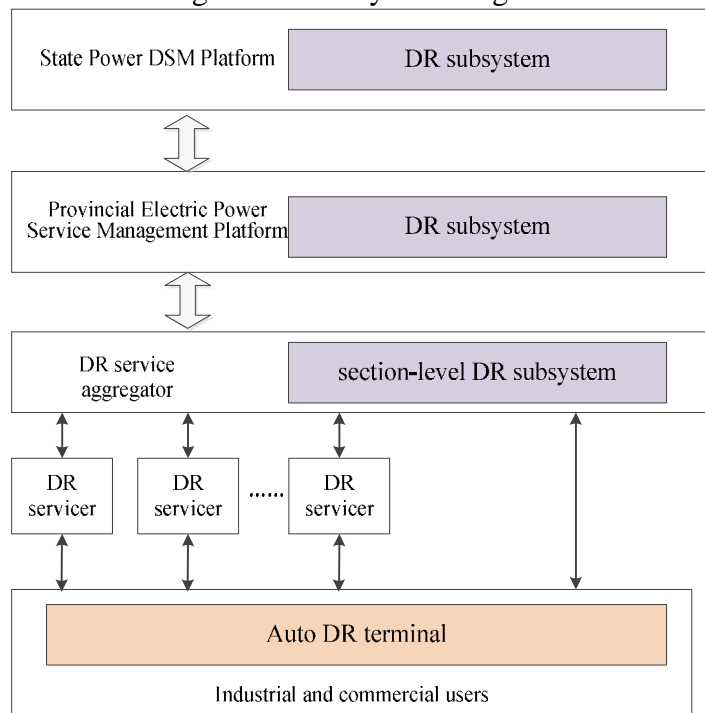

Fig 4 System architecture diagram

Business architecture. According to the demand analysis, State Electric Power DSM DR Platform is divided into three business areas, the operation auxiliary domain, business management domain, platform support domain, as shown in Fig 5.
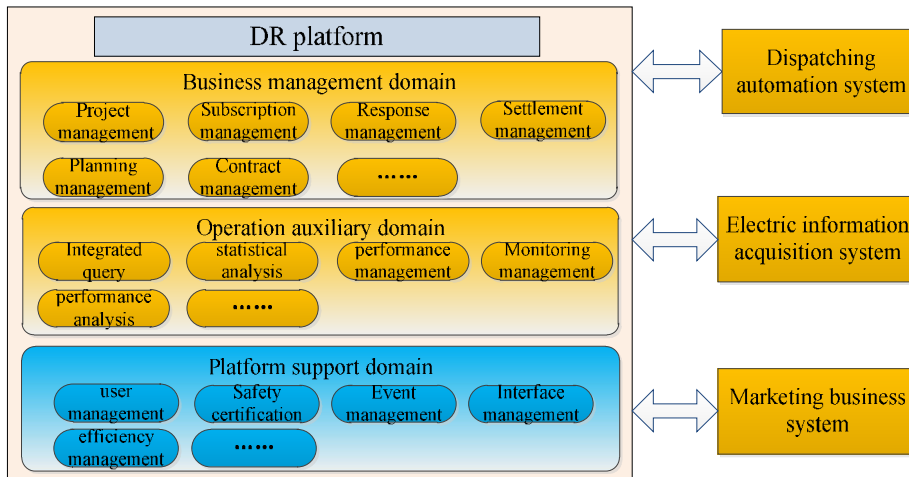
Fig 5 Business architecture diagram

Operation auxiliary domain is mainly providing strategic analysis for management layer, to assist management layer to develop guidelines and strategies.

Business management domain provide users to participate in load reduction plan developed by the DR center, achieving the plan by the way of load apply.

Platform support domain provides basic business for load apply, for example, reporting service, performance evaluation, settlement business, etc.

Function architecture. Through different roles management rights, platform is used by DR center, DR servicers and users. The function architecture of system is shown in Fig 6.
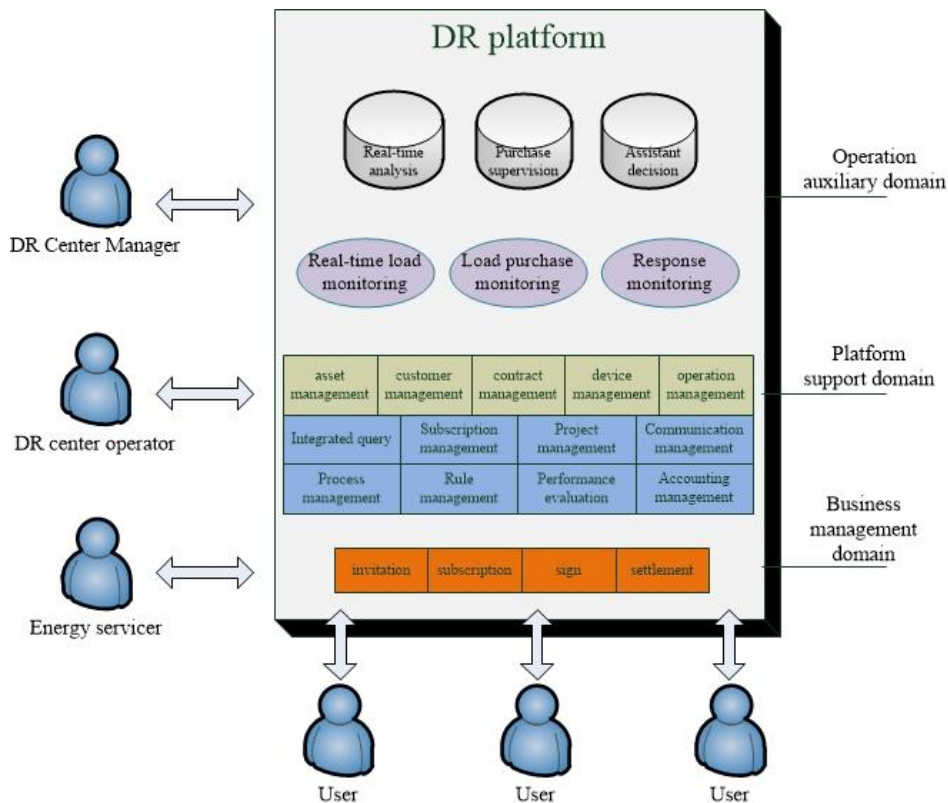

Fig 6 Function architecture diagram

Business process of DR

Process of response. As shown in Fgure 7, DR center receive load reduction demand from the electric dispatching system and other agencies, and develop a load reduction plan according to the location, quality, reputation and other considerations of electric service providers and publish the announcement on the platform. DR service providers view the announcement in time, and then according to the power consumer's ability of load reduction, they confirm the application amount of load reduction and submit it to the DR center. The DR center summarizes the application amount of DR service providers, and if the amount meets the demand of load reduction, the center gets load reduction plan and sent it to DR

service providers, but if the amount cannot meet the demand of load reduction, the center will adjust the plan according to the ability of DR service providers and make an announcement.
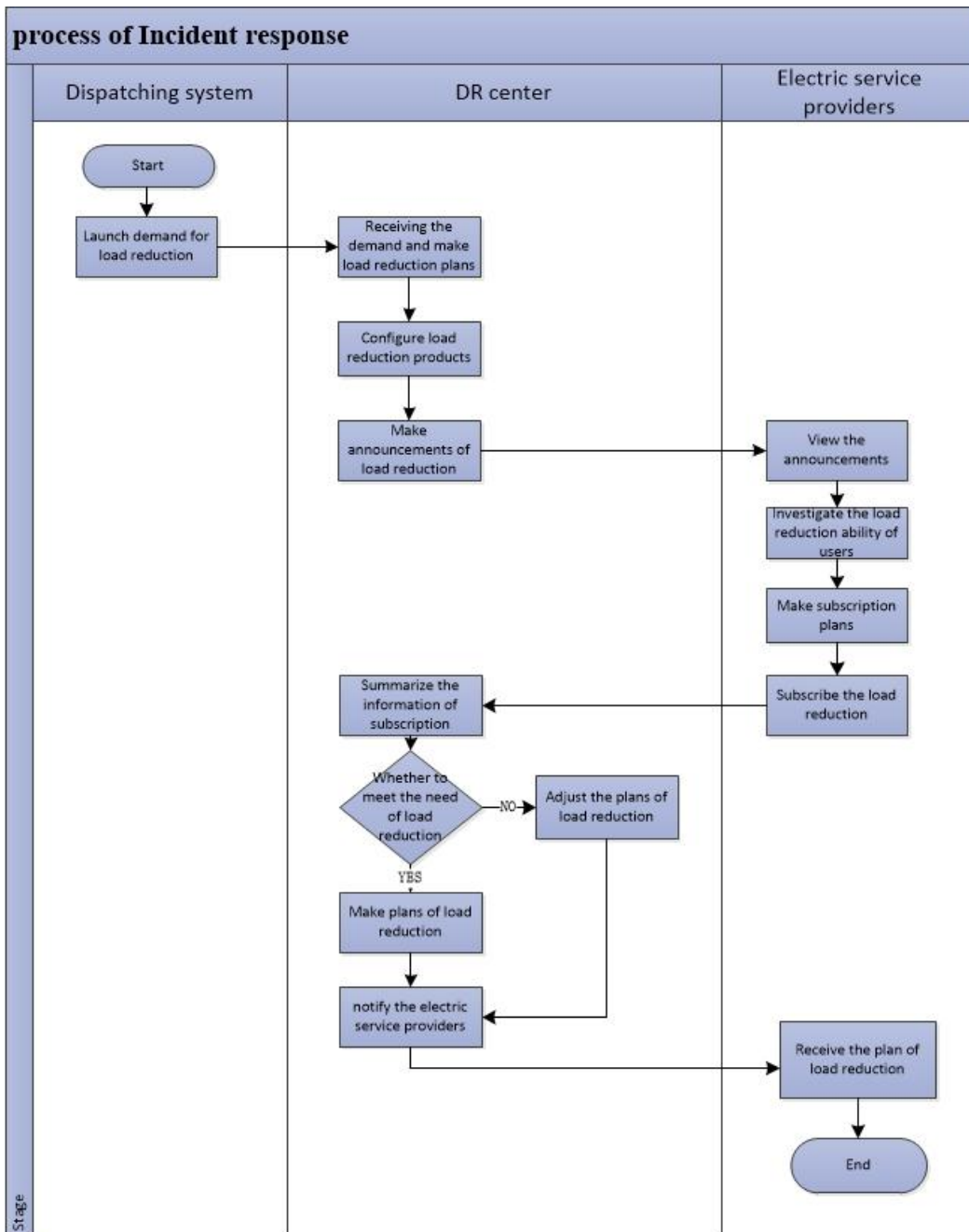

Fig 7 Process of incident response

Execution process. As shown in Fig 8, DR center notify the DR service providers to execute the load reduction plan. DR service providers begin to execute the load reduction plan. At the same time the DR center monitor the load reduction, and if it is found that the amount of load reduction cannot meet the demand, the reserve DR service providers will be informed to execute the load reduction plan. After the load reduction, the performance of DR service providers will be recorded and the evaluation information of DR service providers will be generated.
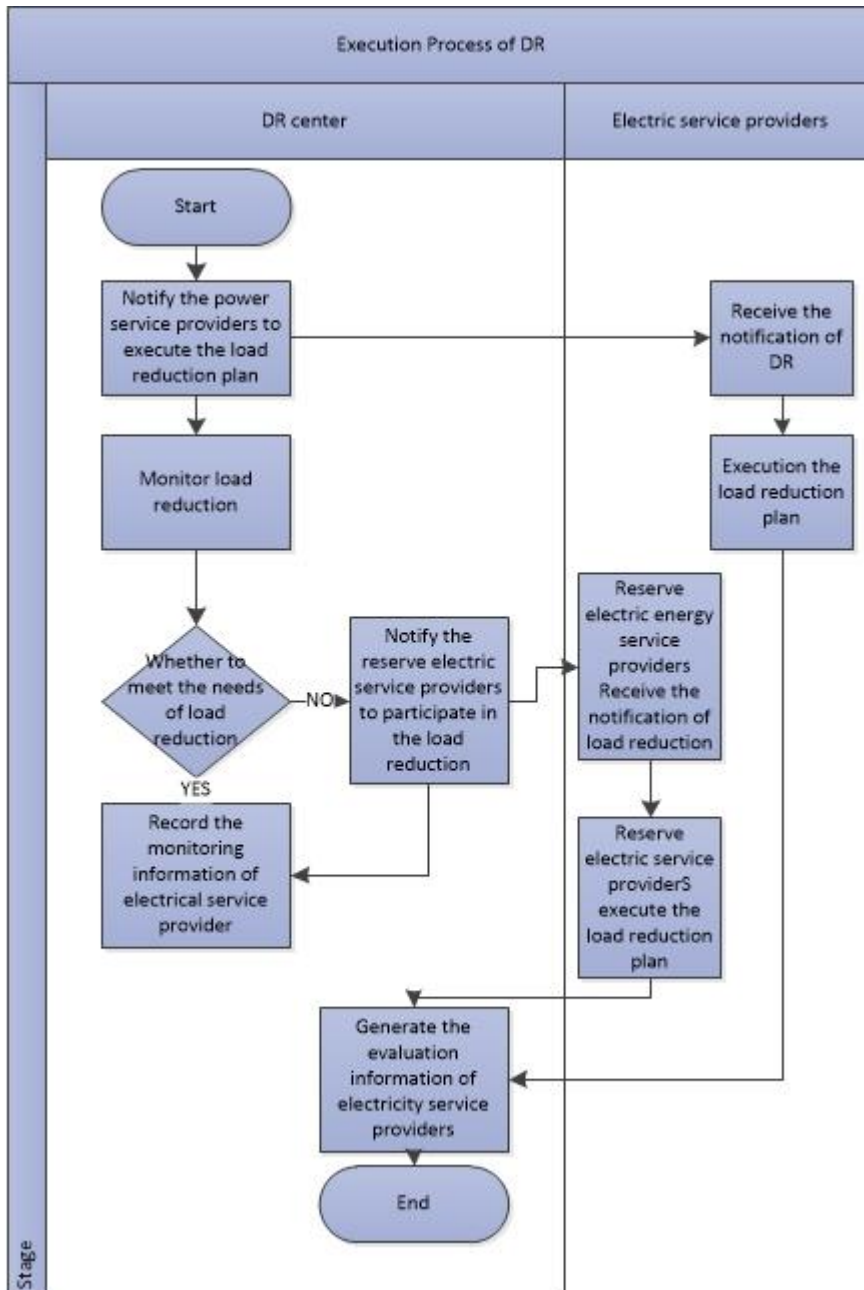
Fig 8 Execution process of DR

Conclusion

An automatic DR implementation mode in an open power sales side market is put forward. According to the test from the automatic DR simulation platform, the proposed business process and architecture were proved to meet the requirements of automatic DR. And it has important guidance function for the standardization of the development of automatic DR, creation of models of auto DR and the expansion of the application scale.

Acknowledgements

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