

# Study of the Techniques and development strategy for a Concentrated Type Distribution Automation

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**Abstract**—Base on the characteristics and application needs of the distribution system in China smart grid, the distribution automation technology and its development strategy are studied with a reality applications engineering. First, this paper makes a particular analysis of the main problems occurred on distribution automation engineering developing now in China. And then some key technology strategies are discussed, including the correlative technology with the concentrated type distribution automation system, the special application needs of the distribution in China smart grid, master station and remote terminal unit of distribution automation system, information integration, of distribution automation system, and so on. Finally, some application examples are given about the above key technology strategies to the several practical projects in China.

**Keywords**-concentrated type; distribution automation; technology strategy; construction strategy

## I. INTRODUCTION

Distribution Automation(DA) is an important technical means to improve distribution dispatch, operation management and power supply reliability, and it is also one of important tasks in the smart grid construction<sup>[1-11]</sup>. With the implementation of the smart grid strategy, automation engineering applications have been started in China, and the apparent effective have been made<sup>[12-16]</sup>.

At present, because the distribution dispatch and operation management lack the its supporting platform of information systems, the low working efficiency and management level has been unable to meet the requirements of the rapid development and social services to the power supply distribution network in China.

According to the distribution network characteristics and the demands of distribution dispatch and monitor, operation management and maintenance to distribution automation.

(electric power business applications), this paper discusses the techniques and strategies in distribution automation construction of State Grid Corporation of China(SG) combined with the distribution automation technology development and actual engineering projects. Based on the comprehensive analysis of actual engineering applications of the concentrated type distribution automation system, expound the main problems, the overall results and developing trends on the construction and application of distribution automation in China.

## II DISTRIBUTION AUTOMATION TECHNOLOGY AND

## ITS CONSTRUCTION STRATEGY

### A. Unanimous Technology Standards and Unified Organization Implementation

Beginning May 2009, China's distribution automation enters a new developing period<sup>[12-16]</sup>. As summing up the past experiences and lessons, SG has explicitly constituted the construction strategy of "unanimous technology standards" and "unified organization to implement". So far seven important enterprise standards have been established, such as the Q/GDW 382 --"Distribution Automation Technology Guideline" (hereinafter referred to as the "Guidelines")<sup>[1-2, 17-21]</sup>. This guideline includes technology standard, function specification, checking and accepting standards and operation and maintenance regulations, etc., and provides a reference sample of a distribution automation construction strategy and technology standard for other Chinese power systems.

### B. Pilot Construction in Center Area of Cities in Batches

So far, the State Grid Corporation of china has chosen 30 important cities to carry out distribution automation in 3 batches. In which the distribution automation system of 23 cities, in the first and second batch, has been built and put into operation, which has accumulated extensive pilot construction and application experiences<sup>[14-15]</sup>. After Shenzhen and Guangzhou, many important cities in Southern Power Grid Corporation, such as Nanning, Guiyang, Kunming and so on, carry out the construction and application of distribution automation, too.

### C. Programme Implemented in Phases Based on Application Objects and Their Needs

In recent years, China's urban distribution network scale is increasing, but more than 95% of the city has no effective technical supporting means for distribution network dispatch and operation, such as remote monitor and control and so on. In fact, the distribution dispatch control and operation maintenance has become two main application needs, and interactive relationship between them is one of the basic characteristics of China's construction and application of distribution automation.

Therefore, it is necessary to constitute the programme implemented in phases, on the basis of a comprehensive feasibility analysis of the application requirements.

### D. Focusing on the development of the concentrated type distribution automation

Although there are many optional technology of the

distribution automation, the concentrated type distribution automation has a greater advantage to meeting the application requirements of operation and maintenance of the distribution network under China's centralized management system. Therefore, it becomes one of the basic principles of constituting technology strategy and construction strategy in China to focus on the development of the concentrated type distribution automation<sup>[1]</sup>. Under this principle, some basic functions are firstly achieved, such as SCADA (Supervisory Control and Data Acquisition) and concentrated FA (Feeder Automation)<sup>[16]</sup>.

So, it is as soon as possible to solve the following problems: 1) To monitor the operation state of the whole distribution network; 2) To handle and control faults; 3) To locate the fault quickly and shorten greatly the time to find the site of failure at the actual locale; 4) To Monitor all equipment operating conditions of the whole distribution network in real time.

#### E. Information Exchange Bus and Its Integrated Apps

As one of the key techniques in distribution automation, the construction strategies of Information Exchange Bus (IEB) include building interaction between distribution automation system (DAS) and correlative systems of power supply company or applications of supporting technique, and information sharing based on existed enterprise information resources. Meanwhile, the technical standard of IEB based on IEC 61970/61968<sup>[22-25]</sup> is already in State Grid distribution automation "guideline"<sup>[1]</sup>. On the basis of IEB, the so-called information isolated island systems such as DAS and EMS can get support from correlated systems conveniently, and apps of DAS can also utilize exchanged information to serve distribution network dispatching center and other operators<sup>[16]</sup>.

#### F. Optical Fiber Communication Technology

DAS has special requirements for communication channels, for example, 1) reliability; 2) security; 3) construction and maintenance costs; 4) communication channel privatization. Certainly, various communication modes that can satisfy these special requirements as follows, wireless communications: public communications networks (3G/GPRS/CDMA), broadband private network (LTE/McWill/WiMAX/230MHz); Power line communications: medium-voltage carrier; line communications: optical fiber, telecom cables. In view of cost performance, construction and operation convenience, the optical fiber communication and EPON(Ethernet Passive Optical Network) technology is proposed, the optical fiber with 24 wire core will be better.

#### G. Develop smart terminal and support the apps

Since the coverage of smart distribution terminals is extensive and its operation status determines the application level, developing smart terminal and supporting correlative apps is one of the fundamental technologies in distribution automation project. However, the development and application investment in this field has always been insufficient and need to be strengthened, for example, 1) System operation stability, including power source, moisture proof work, constant temperature control system; 2) Data acquisition modularization and multiformity, including Data acquisition precision and real-time, Acquisition function modularization, terminal

working condition diagnosis alarm information sending and processing; 3) Information processing performance, including statistical information processing, information interaction between master station and smart terminals and remote maintenance; 4) Telecontrol protocols consistency and network application protocols unitarity; 5) Machine-electricity design integration of distribution primary equipment and smart terminal.

### III. ACTUAL PROJECT APPLICATION OF THE CONCENTRATED TYPE DISTRIBUTION AUTOMATION

#### A. Characteristics of Distribution Network and Correlative Service

1) There are two main types distribution network configuration in Chinese power system: single line overhead radial connection, single/multi line ring net connection; single/multi cable ring net connection;

2) distribution network is sustained by 220/110kV substation, 10kV feeder breaker configured with microprocessor-based protective relaying, 10kV feeder nodes such as RMU only configured with load switch;

3) distribution automation service comprise dispatching and control, operation and management, customer service;

4) EMS, PMS, Marketing management system, GIS and MIS are already in operation in power-supply company, and DAS need information provided by these existed systems.

#### B. Technical program of distribution automation project

1) implementary areas selection: select areas that distribution line and accessory equipment have good operation status, important customers, heave load, high power-supply stability and can satisfy N-1 rules;

2) in order to realize telemeter, tele-signaling and tele-control in backbone distribution line, it necessary to deploy machine electric control, meter, voltage transformer and current transformer in distribution network;

3) select master station communication terminal as the main architecture of distribution automation;

4) master station system adapt UNIX and have three configuration of high-level(more than 500,000 data), mid-level(about 300,000 data) and low-level(less than 100,000 data)<sup>[2]</sup>, usually have 2\*3 small server, 2\*3 maintain or operation workstation, correlated network and storage equipment, and the selection of configuration is mainly based on the amount of information in process;

5) all implemented projects have IEB or common-bus based on technical route of IEB, which is divided into subareas based on real time application and management security, each subarea has one server and one workstation at least. For large scale projects, each subarea has one load balancer, two servers and two workstations;

6) there are three main types distribution terminals, data terminal unit (DTU), feeder terminal unit (FTU), transformer terminal unit (TTU), fault detector and local user fault isolator are only configured in few projects;

7) as described in 1.6, each project adapt EPON in communication plan, and its main configuration is EPON+SDH/MSTP and adapt optical fiber of ADSS with 24 wire cores.

### C. Analyzing of Application Achievements

By the end of march 2012, the construction of 23 distribution automation projects have already completed, last a year and half<sup>[12-16,26]</sup>. The distribution dispatching center and manage departments have obtained the benefits of initial phase project, and construction strategy and technology of DAS described above has been verified. For example as follow:

- 1) Tele-meter, tele-signaling, tele-control and other functions of SCADA;
- 2) The online rate of master station and distribution terminals can reach 99% and 95% respectively, meanwhile, the reliability of communication channels and tele-control functions can reach 96% and 90%;
- 3) Interaction between DAS and EMS have been conducted successfully, and the integrated FA function has been implemented in at least five projects, such as the project of Hangzhou and Chengdu;
- 4) Validity of master station design based on graphic and model has been verified in engineering practice, and GIS tools have also successfully applied to projects of Beijing, Xiamen and etc.
- 5) The main goals of IEB are deploy interfaces, device parameters and information consult function between master station of DAS and GIS, PMS and EMS;
- 6) Technology of EPON has been verified in all implemented projects, which can organize network efficiently and have high stability, meanwhile, Wireless communication technology also has been tested, such as GPRS, which can be an alternated communication in emergency situations;

In addition, for the implemented distribution automation projects, China Southern Power Grid Company has promoted many correlated researches, such as the application and development of fault detector in china southern power grid.

### D. Project Benefit Presentations

In recent years, a series of organized research works has been promoted in distribution automation field by state grid company, which is one of the important achievements in china's smart grid and produces obvious benefits<sup>[12-16]</sup>. The benefits of it are as follows: 1) in implemented areas, real time work condition monitoring, tele-control of backbone line, dispatching and operation of distribution network has been promoted; 2) the time of fault location and restoration in implemented area reduced from 2-3 hours to less than 10 minutes, outage duration and human cost also decreased; 3) FA has been successfully practiced in many projects, for Chengdu project, the scope of FA covers about 190 square kilometers and comprises 300 power lines, the process of fault warning, location and restoration lasts less than 3 minutes. 4) the integrated and stratified configuration of distribution automation has been verified, and application of IEC 61970/61968 used in china's successful cases projects has gathered great experiences, practiced technologies and

construction policies, which can help a lot in expanding scale and promoting application in china's distribution automation projects; 5) management for distribution network and technological improvement in power-supply company has been promoted greatly.

## IV. MAIN PROBLEMS

Through analyzing the distribution automation project in 23 cities of state-grid Company and 10 cities of china southern power Grid Company, the main problems need to be resolved are as follows.

### A. System Operation Maintenance and Application

In order to reveal profitability of distribution automation, the system needs persistent operation and maintenance after establishment, but the operators and managers are inexperienced in this field, and for the disadvantage of system operation and maintenance level cannot satisfy application requirements, a lot of distribution automation are only put initial phase project into operation. The percentage of area and breakers that can be included in monitoring scope is always 10-40 percent in many cities, only Yinchuan, Chengdu and Xiamen can reach 80 percent. Although it has reached original goal of this project, it has low application efficiency.

### B. System Function Development and Application

The state grid company has made distribution automation guideline, functional specifications of distribution automation master station and other correlative technical standards based on IEC 61968/61970, but the implementation of these application functions is very difficult due to shortage of investment in research. Meanwhile, putting the primary application function of systems like SCADA, FA, Web also cannot achieve the expected goals, and functions like state estimation, power flow calculation, network reconfiguration and intelligent warning have large gap between research and practice requirement. so there exist technologic bottleneck in distribution terminals research and application.

### C. Information Exchange and Its Application

As a relation link between the so-called information isolated island systems, information exchange bus is based on IEC 61968/61970, the open interfaces include DAS, EMS, PMS, and etc. Although correlative systems have been linked and validity of technical route has been proved, the problems about insufficient exploitation and utilization in exchanged information still need to be improved.

### D. Application of Distribution Terminals and Communication Equipment

There are many disadvantages in distribution terminals operation, for example huge quantity, extensive coverage, bad operation conditions and high failure rate. Many unforeseen circumstances can exist in practice operation, such as high failure rate in rainy seasons, failure in power source, electric operator and switch contact, and fault in communication equipment and optical cable. The faults above can reach 80% of the total project.

### E. System Security and Application

Since DAS has adopt Network communication mode,

network storm and other problems that can impact system operation stability are as follows: 1) IEC 60870-4 protocol is adopted between master station and distribution terminals, and Ethernet communication mode has come into use; 2) classified VPN based on geographic area is necessary because of the difference in power-supply areas; 3) the front-end network of DAS and EMS have been linked directly to satisfy the dispatching application requirement in many cities (the information of 10kV breaker in substation is forwarded to DAS from EMS).

#### F. Requirement and Application

In general, taking into account of dispatching and operation requirement in distribution automation project design is very important. But all the distribution automation projects that have come into use since 2010 cannot match the requirement because of its small application scale. On one hand, master station has only one construction stage with high investment, and must satisfy the application requirement for the next five years. On the other hand, distribution terminals have multi construction stages with less investment. The terminals that linked to master station actually make up approximately 10 percent of these in plan, so revealing the whole profitability through practical efficiency of initial phase project is very difficult in most distribution automation projects.

#### IV. CONCLUSION

In summary, a pragmatic and effective development path has been found in China's distribution automation construction.

Successful construction strategies mainly include: 1) Unified organization, the standard beforehand; 2) To take full account of the diversity of the distribution network structure in its operating and constructing (building); 3) Planning and carrying out respectively by phases, combined with the difference among the running management patterns of power companies; 4) Multi-batch pilot in small area; 5) To take account of the demand first, and extend gradually.

And successful technology strategies mainly include: 1) establish the series technology specification of China's distribution automation, under the international core standards IEC61970/61968 as the forerunner to support smart grid technology system; 2) Focusing on the development of the concentrated type distribution automation; 3) To take full advantage of a new modern technology to research and develop a new generation of distribution automation devices including a master station, remote terminal unit of distribution automation system, IEB and so on; 4) To practice and utilize adequately the technology and functions, such as SCADA, FA, EPON, information exchange, optical fiber communications.

These successful experiences are worthy of the world's colleagues to share, and the smart distribution network will continue to be developed.

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