REMOTE METER READING IN ZHEJIANG PROVINCE, CHINA

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1 INTRODUCTION

Zhejiang province is situated in the east coast of China. It has a total area of 100,000 square kilometres, about 1 third of Italy. Zhejiang Provincial Electric Power Company (ZPEPC) is the only power utility in the province. The number of its customers exceeds 14,000,000, and the customers at capacity of 100kVA and above take up 2 thirds of its sale but less than 1 percent of its number. After its power plants split out, it is facing more deregulation. To improve customer service and its management, get predominance in the future competition, ZPEPC has been implementing a remote meter reading program covering all customers at 100 kVA and above.

There are some problems that must be solved to establish the system:

- How to manage such a big system, especially to reduce the complexity of maintenance.
- What can the program benefit ZPEPC? Is it a profitable one?
- What advantages can customers get from it?

2 STRUCTURE

This system consists of a main station, channels, substations (terminals) and meters.

Terminal. A terminal is a field data collector and a meter is the main data source for it. It reads the meter by a digital interface, including electric current loop, RS-485, RS-232 and etc. Sometimes more than one meter is connected to it. Some terminals probably contain voltage and current sensors, some Boolean state input such as status of the door of metering cubicle, and some Boolean signal output. Terminals analyze the data to find any abnormal events. The data collected in certain interval and the events concluded are reported to the main station.

Channel. Public networks, such as mobile networks including short message system (SMS), general radio packet service (GRPS) and code division multiple access (CDMA) provided by telecommunication companies, Ethernet provided by Internet service providers (ISPs), are exploited as channels of the system.

Main station. The main station includes front end processor (FEP), Web server (application server), database server and workstations. The FEP is used to manage different channels, receive data from the channels and forward to web server and vice versa. The Web server has the function of data recording, analysis, and providing a platform for operators to communicate with the terminals. The main station is integrated with customer information system, asset management, work flow management and call centre.

3 FEATURES

3.1 Plug and play (PnP) for terminals and meters.

Final number of terminal of the program will reach 100,000. It is a big problem to maintain so many terminals, especially to program them for updated parameters in case of terminal installation and meter alternation.

Terminal parameters. For a terminal working properly, some parameters must be set to it. The parameters include:

- Protocols and addresses of the meters connected to the terminal.
- CT/PT ratio.
- Thresholds for the terminal to decide if there’s any abnormal event happens, for example, maximum normal current to judge if overloading occurs.
- Jobs which will be described in the next section.

Generally, theses parameters are manually set one by one. But there are so many terminals to be installed and a lot of parameters for each. Beside, after the meter connected to a terminal is replaced or any other conditions are altered such as a new transformer installed, the terminal must be reprogrammed with new parameters. It takes tremendous time to complete the process. In addition, many mistakes may occur.

Information integrity. The main station is not an isolated system. It integrates with relevant applications. The process of terminal installation and meter alteration are controlled by work flow software. Once the relationship among a customer, a terminal and a meter is decided in the work flow, all parameter for the terminal, such as normal current, meter address, can be calculated and confirmed automatically without any human intervention.

Self test and auto configuration. Generally speaking, a terminal is well-functioned itself. But it is often uncertain that if it can read the meters connected to it normally and if it can communicate with main station. To ensure a terminal can work well, two stages of communication test, i.e. that between main station and the terminal, and that between the terminal and meters, must be done. The diagram below depicts a typical test in a process of terminal installation:
In the figure above, the messages from main station to a worker are short messages that send to the worker’s mobile phone to indicate the status of a test. Once test begins, the worker has nothing to do but read short messages from his or her mobile phone. Test request can be a certain event reported to main station such as the door of meter cubicle being closed, an action on the terminal such as pressing a button, and also can be triggered in the main station. Meter parameters are the necessary parameters used to communicate with a meter for a terminal, for example the protocol and address of the meter.

Prerequisite. Figure 1 suggests that a test initiates from the terminal. As a prerequisite, the terminal must know where a test request sends to or how to contact with the main station. So before terminals are installed, the main station address must be programmed in advance. The address is the mobile phone number of the main station for SMS communication, IP address for GPRS, CDMA, and Ethernet communication.

State transition diagram for terminal installation work flow. Figure 1 depicts an ideal terminal test process. But sometimes environment does not allow such a test. For example, when the installation meets an outage, the test can not be done. In this case, some other measures must be taken. Figure 2 describes a terminal state transition diagram.

There are 3 stages in the diagram:
- Stage 1: preparation.
- Stage 2: installation and test.
- Stage 3: parameters configuration.

There are 8 actions or events. Among them those with underlines are operated in a work flow of management system, and those without underlines are occurred in the real time system:
- Appoint: appoint a terminal for a customer and create relationship between a terminal and a meter (or several meters).
- Installation plan: about to install the terminal.
- Test request
- Test failed.
- Test succeeded.
- Power on: the event that the terminal is powered on.
- Complete installation: the operation in a work flow that indicates installation is completed.
- Program: a group of parameters are sent to the terminal automatically.

There are 8 states in the diagram:
- Uncertain: it is uncertain for the terminal that where the terminal will be installed.
- Meter related: the relationship between a terminal and a meter or several meters has been created.
- To be installed.
- Testing.
- Installed: the terminal is installed, but test has not succeeded.
- To be programed: parameters are going to be sent to the terminal.
- Working: normal working state.

Other works related to terminals. In addition to terminal installation, there are some other works related to terminals, including terminal alteration, meter installation, and meter alteration. These works are similar to terminal installation. They all include three stages: the preparation stage in which the relationship is created or modified, installation and test stage, and parameters configuration stage.

3.2 Job mechanism

Differences between this system and a general real time system. There are some similar aspects between the two systems, including data collecting, events handling, and sometimes remote control. But there are also some points that make the system differ from others:
- Interval of collecting data is longer than a general real time system.
- Data items to be collect are various and more than the later. For example, active power, reactive power, cumulative total energy of different tariff, maximum demand and so on.
Interval and data items depend on how important the customer is and how electric charge is calculated for the customer.

**Job mechanism in communication protocol.** To deal with the differences described above, job mechanism is adopted in application layer of communication protocol. Several jobs can be defined for a terminal. Each job includes start time, interval, and data item list. Through the mechanism, any alteration of data collecting requirement can be met simply by altering the jobs of a terminal.

### 4 NEW CUSTOMER SERVICES

Before the system established, ZPEPC served customers face to face, or by telephone. Lack of enough information, it can hardly render specific proposals to customers. With this system, ZPEPC serve its customers in new ways with low cost and high efficiency.

#### 4.1 Electrical equipment monitoring

**Content of monitoring.** As what described above, a terminal can monitor some abnormal events. These events include over loading, reactive power over compensation, reactive power under compensation, unbalanced current of three phases, and so on. This information can be offered to customers.

**Message subscribe.** If a customer is interested in some specific events, such as over loading, he or she can subscribe these events.

**Message notification.** When some events such as over loading occur, the terminal will report the events to the main station. If the events are subscribed by the customer, they will be sent to the customer by SMS immediately. The customer can take measures to cope with the events.

**Local control.** If necessary, the terminal can directly control some switches when some specific events occur. For example, some unimportant load can be cut in case of over loading.

#### 4.2 Data query and analysis

With the system, it is no longer necessary for customers to record their power consumption information manually. Active and reactive power, current, voltage and dial indications of a meter are all recorded automatically and consecutively. These data can be exploited to analyze characteristics of power consumption and propose suggestions to improve power utilization. For example, those customers who often run over loading can get the proposal of adding or replacing a new transformer, and those with low load can get the suggestion of reduce their entrance capacity.

##### 4.3 A complex example of personalized service

An important desire of a customer about getting electric power is to reduce electrical charge with satisfied quality. According to the rate schedules of ZPEPC, one way to reduce power payment is decreasing maximum power demand, or the peak active power. The way to help a customer reduce billing demand includes the steps below:

- Analyze power consumption characteristics and propose a reasonable threshold, over which the duration is as short as possible, and between which and maximum load the difference is as high as possible. This can be illustrated as figure 3:

![Figure 3 Threshold of load control](image)

- Program the terminal for the threshold.
- The customer subscribes the service “over-loading”.
- Once the load runs over the limit setting in the terminal, it will report an event to the main station and the main station will forward the event to the customer’s mobile phone by a short message.
- The customer adjust power load to control the demand.
- If necessary, the terminal can be configured to cut unimportant load in over loading duration. In this case, no manual load adjustment is required.

### 5 MANAGEMENT IMPROVEMENT

#### 5.1 Metering facility monitoring

Before the system established, it takes half of a meter reading period, generally half a month in average to find a metering facility fault, such as break of a fuse in potential transformer loop. With the help of this system, these faults can be detected as soon as possible, so that can be handled in 24 hours.

#### 5.2 Energy theft prevention

Thieves of energy exists in some area of China. This may result in a large number of losses for power utilities. The system provides some means for utilities to find or deter meter tampering.
Field monitoring. A terminal can detect some clues of meter tampering, such as short-circuit in current transformer loop, open circuit in potential transformer loop, unauthorized modification of the indications of a meter, and so on. Once a terminal finds these clues, it will report an event to the main station immediately. If necessary, this event can be forwarded to the employees of the power utility by a short message, and the utility can inspect the field and collect evidence in the abnormal duration.

Afterward analysis. In addition to field monitoring, the detailed current, voltage and load data can be used to analyze excessive line losses, unusual load fluctuation and other abnormal phenomena.

5.3 Meter reading automation

As a remote meter reading system, to reduce the work and time of meter reading is no doubt its first mission. Punctual, accurate and detailed meter data are used for billing, line losses calculating and load forecasting.

6 PROCESS AND EFFECT OF THE PROGRAM

6.1 Process

Before the system was widely applied in ZPEPC, a pilot project had been done in Shaoxing branch of ZPEPC. This stage began from 2002. The system is gradually matured and extended to other area of Zhejiang province in 2004. Terminals installed by ZPEPC exceeded 10,000 by November, 2004. The number will probably reach 100,000 in the next 5 years.

6.2 Effective metering facility monitoring

In the three months in which the number of terminals installed in Shaoxing branch increased from 250 to 1000, there are 17 customers, whose fuses in potential transformer loop of metering facilities were broken, found. Monthly energy consumed by them is about 10,000 MWh, and aggregate capacity of their installation is about 60 MVA. Provided that half of the consumed energy was not metered in the failure duration and it takes half a month to find the fault without the terminals in average, the energy prevented from underbilling is about 2,500 MWh, this is to say, about 1.3 MWh/ (month. customer).

Meanwhile two customers, in whose metering facilities current transformer loops were short-circuiting intermittently, were evidenced and prosecuted of energy theft; loss of a line, to which a customer, suspected of meter tampering, is connected, reduced by 150 MWh/month in average after terminal installation. In addition, a damaged junction box, which caused short circuit in a current loop, was detected.

6.3 Easy installation

In the process of terminal and meter installation, no one is responsible for parameter configuration. Consistency and correctness is maintained automatically. It only takes 2 minute to complete communication test in most cases. PnP of terminals makes management of the system easier than any other real time systems.

6.4 Load management and forecast

China has been suffering electric power crisis in 2004 and Zhejiang province is the most serious one in the crisis. Some policies about load control are issued by the government. This system is effectively exploited to monitor that if customers restrict their load under limitation and remotely switch off those loads which break the decrees.

With the detailed power load information, the load characteristics varying with industries, seasons, weather, temperature and time of a day can be analyzed. This provides prerequisite for more accurate load forecast.

7 CONCLUSION

Remote meter reading for the big customers improves the management of ZPEPC, brings economic benefit, and will enhance its competitive strength. Any way, this framework seems not adaptable enough. The technologies below are considered and may be adopted by ZPEPC:

Terminal-imbedded meters. Such a meter integrates a traditional meter and a terminal into one object. This will simplify the structure of the system and reduce malfunctions.

Power-line carrier (PLC). ZPEPC had employed PLC for residential customers. But it was not effective. With the development of PLC technology, it may be considered again, especially in rural areas.

Multi-stage remote meter reading. Combine with PLC, public network and any other appropriate channels, multi-stage remote meter reading may be a better resolution for some customers.

REFERENCES

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