PRINCIPLES OF EFFECTIVE ENERGY MANAGEMENT AND POWER CONTROL SYSTEM

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Abstract: This paper aims to emphasize the approach on energy management with its principles and give a general overview of this field of industry. The basic functionality of power system control is found in the Supervisory Control and Data Acquisition (SCADA) function that collects and records values and statuses acquired from the power system elements via remote telemetry to enable control center operators to supervise and control the power system.

Keywords: monitor, power, process, management, energy.

1. INTRODUCTION

Maintaining a reliable supply of electrical power to consumers is a highly complex process as most of this power cannot be stored and the individual elements of this process, forming what is called a power system, can be spread over a wide geographical area [7], [12].

The aim of power system management, also referred to as Energy Management, is to monitor, control and optimize this process in real-time. The basic functionality of power system control is found in the Supervisory Control and Data Acquisition (SCADA) concept that stores values and statuses acquired from the power system wirelessly to enable control center operators to control the system [9].

Other decision support functions complement this function to provide power system management for a secure and optimal process.

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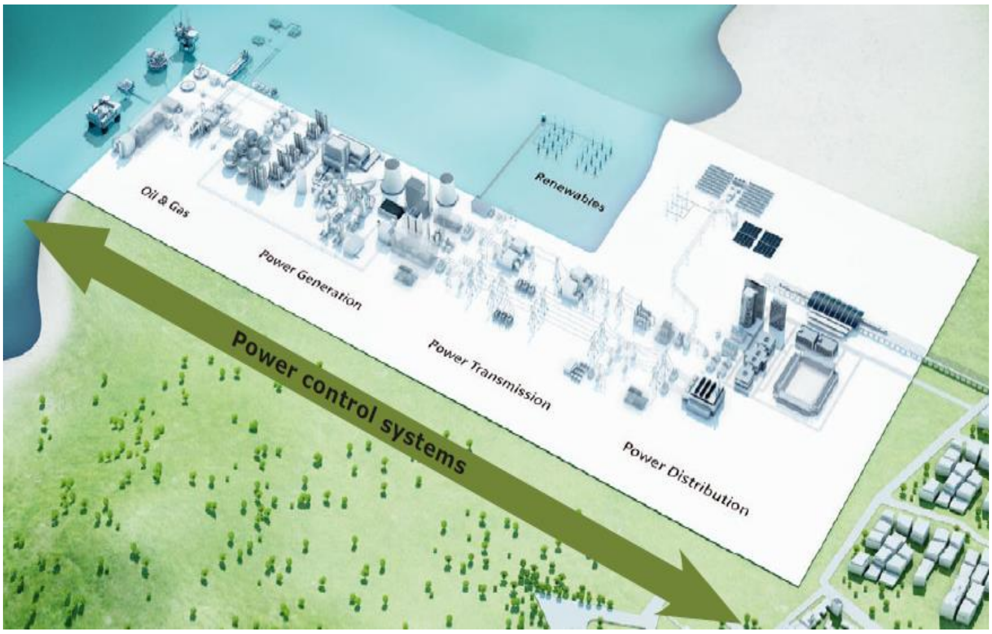

Fig.1. Power control system – serving the complete energy chain from generation to load

With the help of network control systems, the operators can obtain information from the network in real time, and they can then use that info the basis for optimizing the control of the power supply [6], [11].

The info transmitted by the station automation systems wirelessly must be stored and processed at a hub. This function, is well realisez by network control systems that are installed at central areas, which are also known as system control rooms.

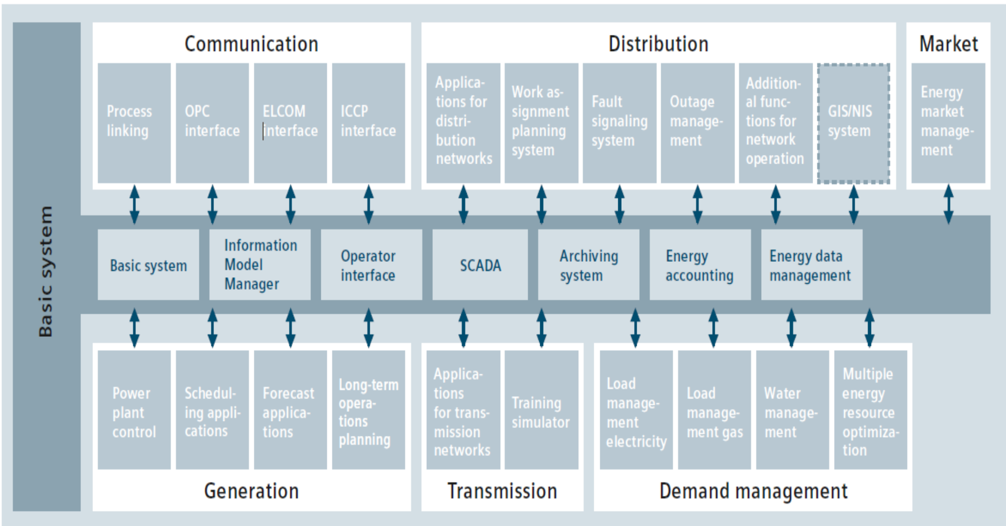

Fig.2. Power control system, element overview

The result of these many years of experience is the development of control systems for electric power systems as well as for gas, water and district heating networks (fig.2).

On the basis of a minimum configuration for operation, it is possible to add subsystems to meet the other requirements in terms of additional functions, structure and size of the system [3], [8].

With its modular structure, the system can be expanded with little effort, even subsequently.

Block modules can be swapped or new modules can be added to meet the required modifications. On the basis of the standard system, open programming interfaces permit individual adaptations and subsequent expansions for new or existing customer-specific elements. In one basic configuration a control system comprises the following elements, which are described here:

- Basic services

To be sure that the fundamental functions are provided like real time database services, data exchange and coordination of PCs involved in the control center

- UI (User interface)

For providing friendly, powerful and pleasant graphics oriented to the operator

- Information model management

For data entry and data maintenance, single line diagrams and data exchange with other computer systems

- Communication front end

For better interface of the field remote terminal units, with the process

- SCADA applications.

Fig.3. Control room

For implementing the functions required for system operation, i.e., system monitoring and controlling. In addition to these elements, the following subsystems, which are described in greater detail in the remainder of this section, are available for expanding the functionality [4], [13]. They are used and configured to match the tasks and size of the control systems:

- Historical information system
  For the archiving and subsequent reconstruction of the process data.
- Forecasting applications
  For the long-, medium- and short-term forecasting of system loads
- Power control applications
  For the monitoring and control, i.e., real-time dispatching, of the power generating units participating to frequency regulation
- Transmission network applications
  For fast and comprehensive analysis and optimization of the transmission network operation
- Training simulator

For training the operator to all range of network behaviors with the tools and user interface as used in operation.

Real-time processing

SCADA software are basic functions of the network control system and gives means of controlling the power supply system. For this aim, all info transmitted from the network is stored, processed and displayed in order to keep the operator constantly informed about the current operating state of the power supply system.

The human operator can also store additional data in the system or enter corrections for incorrectly reported [1].

2. APPLICATIONS FOR BETTER MANAGEMENT IN DISTRIBUTION NETWORK

A distribution network is characterized by a mostly radial and lightly meshed structure, which is operated mostly radial. The distribution network, typically includes a medium voltage (MV) part, a low voltage (LV) part, and is interconnected to the transmission network at HV/MV substations [2].

Under the Smart Grid pressure automation of the MV/LV substations is now accelerating in Europe whilst automation of the MV feeders is now accelerating as well in the US. For these reasons telemetry, that of power flows, is relatively limited but rapidly increasing.

Maybe the most important application in distribution network, is the outage management that is responsible for the management of all planned and unplanned outages, the latter part being also referred to as Fault Management. Outage Management integrates information from SCADA (events), metering (events), and customers (trouble calls) to infer one or more concurrent network outages. With the additional help of crews and support from analysis tools, operators are then able to promptly locate faults, isolate faults and restore service. Outage Management will also provide calculation of efficiency indices that are typically required by the regulator to assess the efficiency of the utility towards its customers. Outage Management with the support from analysis tools provides also for the coordination of planned outages with the normal operation of the network to ensure safety of the crews and continuity of service to the customers.

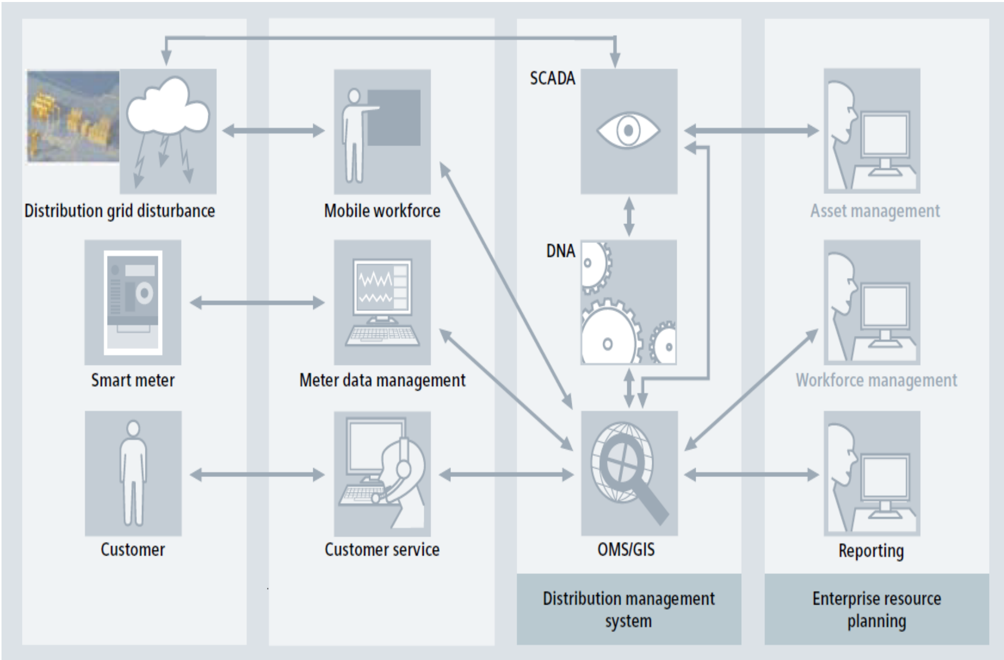

Fig.4. Schematic workflow in a distribution management system

3. TRAINING SOFTWARE SIMULATOR

The increasing complexity of existing power systems places increasing demands on operation personnel. Efficient training simulators are therefore required for carrying out the necessary comprehensive hands-on training. The following areas can be covered with training simulators:

- Familiarization of operation personnel with the control system and the existing network
- Training of experienced personnel to changes in network, operating procedures, tools, etc.
- Training of personnel to daily work as well as to emergency conditions (like blackouts)
- Simulation and analysis of operational incidents (post-mortem or anticipated) towards improving on existing operating procedures
- Testing of possible network expansions and analysis of alternatives, testing of new tools and analysis of results, etc. For the training of personnel, training simulators must reflect accurately the power system behavior and provide to the operator the very same tools, including visualization, as those used in the control center for an effective training. The training simulator includes 4 essential elements:
- A training management element
- A power system simulation element
- A telemetry simulation element

- A copy of the management system (EMS, TMS, DMS or GMS).

The power system simulation element is responsible for the accurate simulation of the dynamic behavior of the managed system, i.e., that of all its field equipment (generating units, network and loads). The telemetry simulation element feeds into the management system copy the simulated field data as they would normally come from field equipment into the control center [5].

This training simulator also provides to the trainee an environment identical to that used in operation and to the instructor an environment that allows him to create training scenarios, influence (with or without knowledge of trainee) the training session, etc.

4. OPERATOR TRAINING SIMULATOR (OTS)

OTS is based on 4 key elements:

- A training management element
- A power system simulation element
- A telemetry simulation element
- A copy of the control system

The training management element provides tools for creating training sessions, executing training sessions and reviewing trainee efficiency. It provides tools to:

• Initialize the training session, like, from real-time or a saved case

• Define the system load profile

• Create event sequences, like, a breaker opening, a telemetry failure, etc., that can be either time triggered, event triggered or command triggered

• Create training scenarios, i.e., a number of event sequences, to be activated during the training. It also provides start/stop and pause/resume functions for the execution of the training session. During the training session it is possible for the trainer to create new events and/or modify the running scenario [10].

The power system simulation element provides a realistic simulation of the power system behavior to support training from normal operation to emergency operation including islanding conditions and blackout restoration. The simulation is based on a long-term dynamic modelling of the power system including:

- Load modelling with voltage & frequency dependency
- Generation modelling with governor, turbine/boiler and generator models
- Frequency modelling
- Voltage regulator modelling
- Protection relay modelling
- External company LFC modelling.

The telemetry simulation element provides the simulation of the data communication between the power system and the control system. It transfers as simulated field telemetry the results of the power system simulation to the control system copy. And it processes all commands issued by SCADA, LFC, etc. and transfers them to the power system simulation.

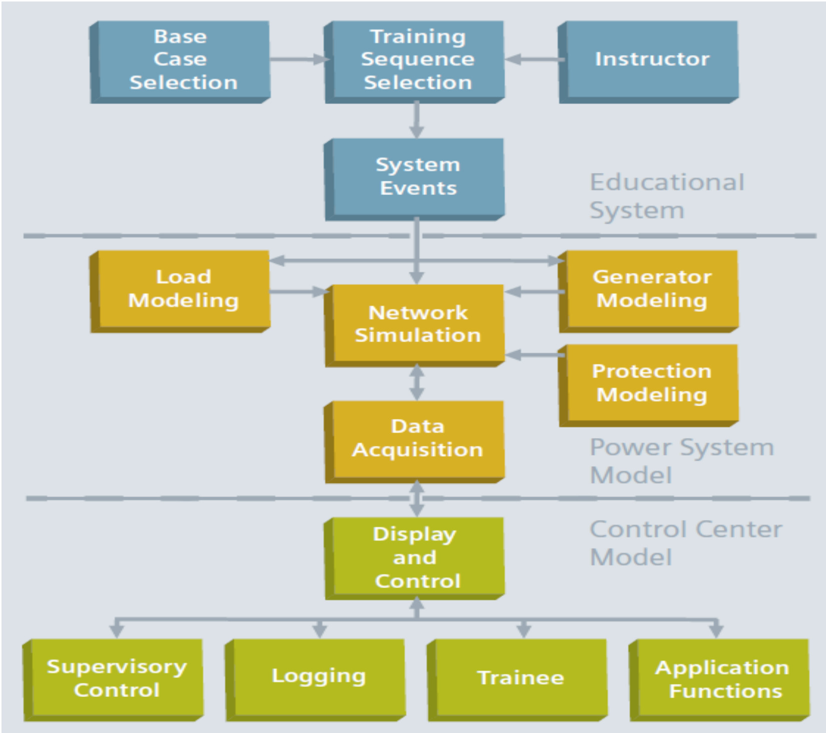

Fig.5. Block diagram of a training simulator Multi-utility

This simulated telemetry, can be modified via the scenario builder by the trainer to reflect measurement errors, telemetry or RTU failures, etc. This operator training simulator provides a dedicated environment for the trainee (operator) and one for the instructor that allows the instructor to influence the process in order to force responses from the trainees. The trainee interface is identical with that of the control system so that, for the trainee, there is no difference in functionality and usability between training and real operation.

5. CONCLUSIONS

Having the opportunity to simulate the management of a power system is highly useful for the operators, thus the efficiency of their decisions in the real management structure will be better correlated with the requirement and situations.

Some distribution utilities will manage the distribution of multiple commodities, like electricity, district heating, gas and/or water. Whilst the distribution process, for example with load management, is commodity specific, inter-dependencies will be created either by the procurement process or the production model.

It is not unusual to find in distribution cogeneration power plants, also referred to as combined heat and power (CHP) power plants, providing electrical power and district heating.

Management of these 2 highly integrated commodities will require adapted tools accounting for the high inter-dependencies existing between the production and the demand of these 2 commodities.

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