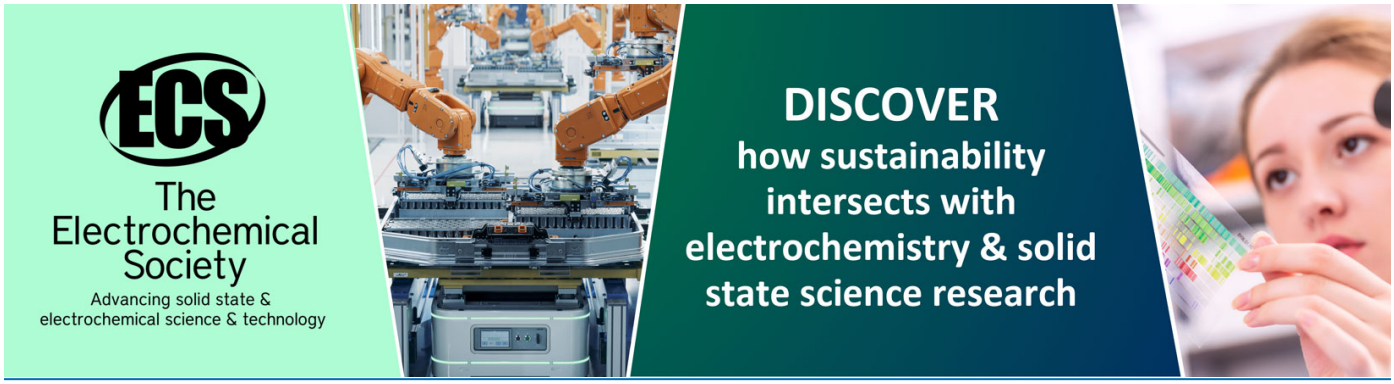
The main directions of development of active-adaptive electrical networks for agricultural purposes



The main directions of development of active-adaptive electrical networks for agricultural purposes

A F Shatrov[1], N A Stushkina[2] and T B Gaitova[1]

[1] Moscow Polytechnic University, Moscow, 38, Bolshaya Semyonovskaya str., 107023, Russian Federation
[2] RGAU-MSHA named after K. A. Timiryazev, Moscow, 49, Timiryazevskaya st., 127550, Russian Federation

E-mail: energo-stushkina@mail.ru

Abstract. The article discusses the possibility of building intelligent (active-adaptive) electrical networks for rural purposes using a SCADA system in automated control systems for energy facilities.

1. Introduction

One of the main resources for the development of the agro-industrial complex is a reliable and high-quality power supply to electrical equipment and agricultural enterprises. Actively adaptive (intelligent) electrical grids in general solve this problem not only for the purposes of the agro-industrial complex, but also for other sectors of the economy.

Actively adaptive electric grids will become the "mainstream" of the development of the electric grid economy today and in the future, as well as an important factor in increasing the energy efficiency of the power supply system in the interests of electricity consumers. Active-adaptive electrical networks include interdistrict and local networks with voltage from 0.4 to 220 kV and above. They provide electricity to all types of agricultural enterprises, farms and the population of agricultural areas.

2. Materials and methods

Analysis of the stages of development of active-adaptive electric grids makes it possible to distinguish several groups that can be considered basic for smart electric grids.

These groups include primarily:

- Instrument base of measurements (EIM-electronic measuring devices);
- Intelligent meters and sensors;
- Automatic control systems (ACS TP, etc.);
- Systems including intelligent devices, distributed over a controlled system, means of transmitting and receiving information, supporting the hierarchical structure of energy facilities management with on-line information transmission; software (SCAD / EMS / NMS systems) using new algorithms and controls in its work. The operation of these algorithms can be based on active intelligent elements of electrical networks;
- Modern developments and components of the power system. Among these developments, FACTS-1 and FACTS-2 flexible AC transmission lines should be considered. These lines are

based on superconducting cables that are not exposed to temperatures, automatic monitoring and control devices, modern power elements of electronics and others;

- Systems of justification and control of decision making. These systems include: SCADA - a system that allows you to monitor and manage business processes in real time; DMCS - monitoring and control system at all stages of the controlled process; DGMS - a system for executing the current stage of the controlled process; AMOS is a system for automatic measurement of parameters of controlled processes, etc. The above systems are based on modern IT solutions that are used at the design stages of the power system to select the main equipment and modes of its operation.

IT solutions consist of:

- Systems for transmitting and receiving information, implemented in the power system. Information transmission and reception systems implemented in the power system allow transferring information about the operation of the entire power system between the first five areas of development and ensure the specified parameters of the power system. An example of such a system are automated substations, which are based on software and hardware complexes of APCS systems, developed taking into account the international standard IEC 61850;
- Electricity control and metering systems, distributed over the hierarchical levels of the power system;
- Information and digital communication systems: power lines; systems for monitoring the occurrence of transient processes WAMS (Wide Area Measurement System); automatic protective equipment systems installed at all hierarchical levels of the WAPS (Wide Area Protection System) power system.

Today, the urgent task is the implementation of projects by the state organization "ROSSETI". First, these projects are related to the production and installation of millions of smart electricity meters and the automation of dispatching processes implemented by the SCADA system.

The task of matching the consumption and production of electricity and other resources is one of the main tasks in the modern electric power industry.

Traditional electricity meters mainly used today measure only the total amount of electricity consumed and do not provide information on the temporary consumption factor. In this regard, smart electricity meters are a tool that enables electricity suppliers to obtain information on the amount of energy consumed over time. Based on this information, the energy supplying organization can regulate the differentiated electricity tariff, taking into account specific periods of time (two- and three-tariff electricity meters). It also becomes possible to fully control the consumption of electricity and, based on this data, into the ability to manage energy consumption.

3. Results

A consumer can save about 3-4 kW · h of electricity if he reduces his electricity consumption by 1 kW · h. Thus, reducing electricity consumption by a specific user is one of the real ways to save electricity.

Taking into account the daily and annual load schedules, we can conclude that the cost of 1 kW · h of electricity on the market will be the maximum value at a specific time of the day and year. The cost of electricity can increase significantly if the purchase of electricity is carried out from related energy supplying organizations at an inflated price. In addition, the price of 1 kW · h of electricity can be significantly affected by the commissioning of their own expensive generating plants (wind generators, solar power plants, etc.) power consumption. All together, in our opinion, will lead to a stable and rapid decrease in the price of electricity. In particular, this approach leads to the creation and mass installation by consumers of two - and three-stage smart meters.

The main thing for smart meters is the automatic reading of the consumed electrical energy and / or its generation by the consumer (Figure 1) with the subsequent transmission of this information to the power supplying organization in on-line mode. Automatic control systems for electricity consumption are usually implemented in one of two ways, taking into account specific legislation.

The first method is to use the metrological capabilities at the end point of the measurement (electrical equipment).

The second method is focused on reducing costs by reducing functionality.

Regulatory authorities (for example, CDU, ODU, etc.) have strict requirements to prevent data loss and storage, and to ensure guaranteed accuracy of measurements required for billing. EI readings are taken at relatively short intervals (every 15 minutes), and the collected data is transmitted to the operator at longer intervals (every 8 hours). To protect against possible loss of information during data transfer, the rules require that at least two data samples are always stored at the measurement point. Therefore, the metrology chip must accumulate and store data for the last 16 hours of operation.

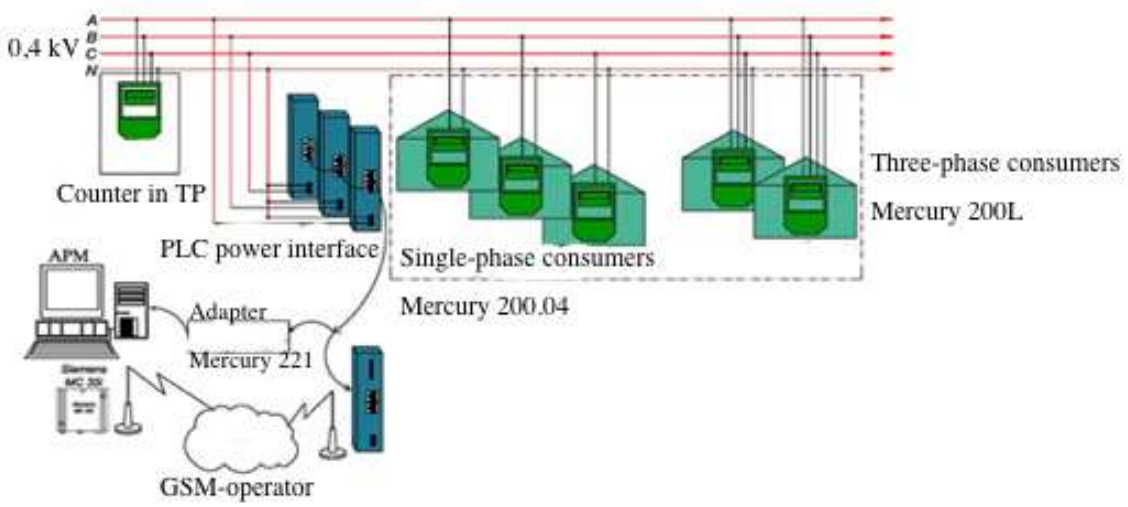


Figure 1. Schematic diagram of the inclusion of smart electricity meters.

4. Discussion

The SCADA (Supervisory Control And Data Acquisition) control system is used as a software development tool for process control systems and real-time data collection. Sometimes the term SCADA system is used to refer to a hardware and software complex designed only for data collection. In our case, the main task of SCADA systems is to ensure the interaction of the operator with the technological process of production and consumption of electricity.

SCADA-system implements the following main functions:

- Collection and storage of data on consumption and production of electricity;
- Management of technological processes of production and consumption of electricity based on the collected data and established criteria.

SCADA software - includes systems:

- Development environment designed to create mnemonic schemes; selection of input and output signals of system elements; adaptation of signal parameters to hardware; development of control algorithms; determining the operator's right;
- The runtime environment is intended for the use of a specialized software product;

- I / O servers are designed to work with various industrial controllers.

Figure 2 shows a schematic diagram of the SCADA system architecture.

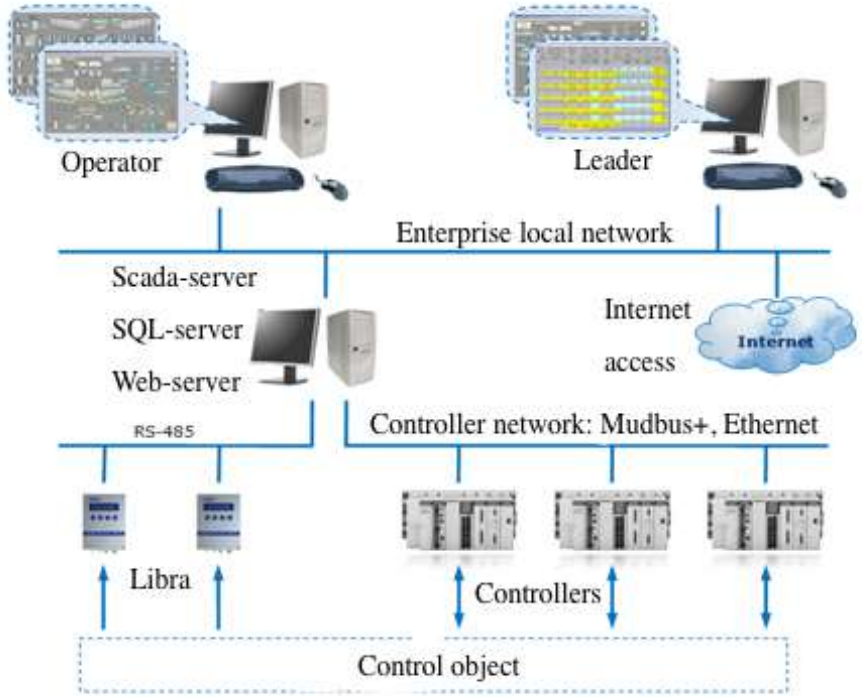


Figure 2. SCADA architecture - systems.

5. Conclusion

The implementation of the directions of development of active-adaptive electrical networks at the power grid level described in the article will significantly solve the problems of increasing the efficiency, energy saving and reliability of power supply to agricultural enterprises, which ultimately may result in a decrease in electricity tariffs.

References

[1] Kolosok I N and Korkina I S 2012 Cybersecurity analysis of a digital substation from the standpoint of a cyber-physical system. *ELECTRIC POWER. Transmission and distribution* **3** 10
[2] Pins S V 2011 Controlled shunt reactors for electrical networks. Problemele energeticii regionale **3(17)** 3
[3] Shatrov A F 2014 The role of smart grids in energy saving and increasing the efficiency of electricity transport. *Electricity saving and water treatment* **3** 3
[4] Shatrov A F 2015 *Optimization methods in power supply problems* (Moscow: Nestor) 126
[5] Ametistov E V 2008 *Fundamentals of modern energy* (Moscow: MPEI) 678
[6] *Intelligent electric power systems: concept, state, prospects* Retrieved from: www.transform.ru.
[7] *Grid 2030: A National Versionfor Electricity's Second 100 Years. Office of Electric Transmission and Distribution, United State Department of Energy, July 2003* Retrieved from: https://www.energy.gov/oe/downloads/grid-2030-national-vision-electricity-s-second-100-years

[8] *European Smart Grids Technology Platform: Vision and Strategy for Europe's Electricity Networks of the Future. European Commission, 2006* Retrieved from: https://www.edsoforsmartgrids.eu/policy/eu-steering-initiatives/smart-grids-european-technology-platform/
[9] Paul Jarman, Patrick Hynes, Trevor Bickley, Alan Darwin and Nigel Thomas 2006 *The specification and application of large quadrature boostersto restrict postfault power flows* (Cigre) 207
[10] *Regulations on the technical policy of FGC UES* Retrieved from: pdl-energo.ru.
[11] Guzhov S V 2015 *Methods for determining and confirming the energy-saving effect in heat and power supply systems* (Moscow: MPEI Publishing House) 112
[12] Shatrov A F and Stushkina N A 2020 Information structure of intelligent networks. *TSKhA: Collection of articles* **292(I)** 4