N.L. Batseva, I.A. Chesnokova
V.Ya. Ushakov, D.S. Nikitin
T.Y. Khohlova

Digital Power Industry

Practical self-study course for students in English

TOMSK POLYTECHNIC UNIVERSITY

N.L. Batseva, I.A. Chesnokova,
V.Ya. Ushakov, D.S. Nikitin, T.Y. Khohlova

Digital Power Industry

Practical self-study course for students in English

Recommended for publishing as a study aid
by the Editorial Board of Tomsk Polytechnic University

Tomsk Polytechnic University Publishing House
2020

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
Федеральное государственное автономное образовательное учреждение высшего образования
**«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

**Н.Л. Бацева, И.А. Чеснокова,
В.Я. Ушаков, Д.С. Никитин, Т.Е. Хохлова**

Цифровая энергетика

Практикум на английском языке для самостоятельной работы студентов

*Рекомендовано в качестве учебного пособия
Редакционно-издательским советом
Томского политехнического университета*

Издательство
Томского политехнического университета
2020

УДК 811.111’243(076.5)
ББК Ш143.21–923
Ц752

Ц752 **Цифровая энергетика. Практикум на английском языке для самостоятельной работы студентов:** учебное пособие / Н.Л. Бацева, И.А. Чеснокова, В.Я. Ушаков, Д.С. Никитин, Т.Е. Хохлова. – Томск: Изд-во Томского политехнического университета, 2020. – 55 с.

В пособии представлены задания, выполняемые индивидуально – работа с поддерживающие тексты, самотестирование и групповые задания – подготовка к решению кейсов, деловых игр. Изложены материалы, способствующие организации научно-исследовательской работы студентов на английском языке для написания докладов на конференции.

Предназначено для самостоятельной внеаудиторной работы на английском языке магистрантов, обучающихся по образовательной программе «Цифровая энергетика».

УДК 811.111’243(076.5)
ББК Ш143.21–923

Рецензенты:

Кандидат педагогических наук декан факультета иностранных языков ТГПУ
И.Е. Высотова

Кандидат филологических наук, доцент ТГПУ
Ю.А. Зеремская

Content

Unit 1. What is a case study and how to solve it?

Introduction

Implementation of a case study in the educational process is a relevant objective [1-5]. This is due to a) the focus of modern education on developing professional competencies, mental skills and abilities, personal qualities, especially abilities to learn and process information and b) changing requirements to employees' qualities, who must be able to rapidly respond to emerging problems, be consistent and effective.

A case-study method is a method of active problem-situation analysis based on learning by addressing specific problem (cases). It is an active imitational teaching method, which can involve role-playing. A case study is a form of continuous assessment, aimed at developing students' skills, personal qualities and acquiring knowledge based on analyzing and solving a problem-based situation with reference to professional activity.

A case study is a verbal description of a problem situation to be discussed and some statistical data that support the study. Students are offered to analyze a real situation, get outside a problem, and suggest options to solve it using current knowledge and extra sources of information. It enables students practicing real-life situations and assuming the role of a decision maker.

1.1. Glossary

A case task (Latin «casus») is an event, an accident, a legal case which can be used to try and test theoretical ideas.

Case-method is a method of actual situations.

Case-study is a training technique, which uses a description of real economic, social and business situations and focuses on improving skills and gaining experience.

1.2. Aims and objectives of solving a case study

The aims of the case study are to:

a) develop abilities to critically analyze problem situations using a systematic approach, and develop an action plan;

b) develop practical skills to work with information;

c) develop an ability to state aims and objectives of research, prioritize the tasks;

d) learn how to make managerial decisions and useful criticism;

e) practice modern communicative technologies, including foreign languages for academic and professional cooperation;

f) increase motivation for learning and professional development, as well as for developing soft skills:

g) learn how to manage and supervise the team, working out a team strategy to achieve the desired goal;
h) develop flexibility;
i) develop an ability to adjust conflicts;
j) learn how to persuade and compromise.

The objectives of a case study are to:

a) master skills and techniques to analyze situations in the workplace;
b) learn how to require extra information necessary to clarify the initial situation;
c) learn how to apply theory to the practice;
d) develop skills to make decisions in a situation of uncertainty, to state your point of view clearly and precisely in oral or written form;
e) practice making presentations, i.e. in a convincing way present, prove and defend your point of view;
f) practice skills of critical assessment of alternative opinions;
g) learn how to make decisions following the analysis of the situation.

In addition, interdisciplinary skills and abilities are practiced, since developing a solution may require knowledge from other fields and professions.

The result of a case study is an intellectual product – an alternative solution to the problem.

1.3. Requirements for a case study, its structure and volume

Requirements for a case study:

a) to present a pressing challenge;
b) to describe a problem in plain language, in a clear and challenging way;
c) to comply with the majors on the syllabus and/or students' future professional activity;
d) not to provide any clues on solving the problem;
e) to contain necessary and sufficient information to perform a task.
f) A case study has an introduction, main body and conclusion.

The introduction provides general information: a glossary of terms; input data; key aspects; statement of issues to be investigated.

The main body states the problem.

The conclusion provides additional information, which can help to gain a deeper insight into the case study: questions; bibliography; photos; diagrams; tables.

In terms of volume there are full, brief and mini case studies. A full case study (20–25 pages) is designed for team work, which results in a team presentation about a solution. A brief case study (3–5 pages) is supposed to be discussed and done in class. A mini-case (1–2 pages) is also done in class as an illustration of the theory studied in class.

1.4. Teacher's role

a) to design case studies;
b) to introduce students to the case study, deadlines, and assessment criteria for the solutions;
c) to arrange a presentation of solutions;
d) to organize a discussion;
e) to make an analysis of the situation;
f) to assess solutions.

1.5. Stages of a case study

A case study is the result of students' individual work.

The process has some stages.

The 1st stage is a preparative. Students read the case, get an insight into the problem and its aspects, as well as the theoretic work material for self-study. A deeper analysis will follow later. Team members work individually.

The 2d stage – students identify the main and secondary problems and develop the structure of the solution (i.e., generate and organize the ideas, hypothesize and prioritize the solutions).

The 3d stage is assessment of all alternative solutions and analysis of their possible outcomes. The students are expected to work with information resources and test hypothesis.

The 4th stage – students are supposed to generate a final solution, e.g., a set or sequence of actions. Following the analysis and verification of hypothesis, the results must be summarized and conclusions made.

The 5th stage is preparation of the solution. At this stage a plan for implementing the solutions is developed, including risk assessment and possible ways to reduce them, as well as the cost and economic effect following implementation of the solution.

The 6th stage is presentation of the solution, a general discussion and summing it up. The success of the solution directly depends upon the quality of its presentation.

1.6. Assessment

The solutions of case studies are assessed against certain criteria. The assessment system focuses on two groups of skills and abilities. The first group includes an ability to work with information and analytical skills (hard skills): relevance of the answer to the task, the structure and logics of the solution, breadth and depth of the analysis. Breadth means studying all relevant and important aspects of a case study, while depth implies their detailed analysis using necessary data, calculations and making conclusions. The second group includes communication and interaction skills (soft skills): how to present the solution, reply to questions, and work efficiently in a team.

The assessment criteria for case studies are given in Table 1.

Table 1

Assessment criteria

Criterion	Assessment and description			
Group 1 The ability to work with information and analytical skills (hard skills)	4-5 points	2-3 points	1 point	0 point
Relevance of the answer to the questions raised	All questions are fully answered	60% of questions are answered	Less than 30% of questions are answered	There is no clear answer to any question
Structure and logics of solution	The structure of the solution is uniform, similar criteria are used for the analysis. The solution is logical, well-reasoned, thematically linked, not messy.	The structure of the solution is uniform, similar criteria are used for the analysis. However, there is no unified logic of the solution; it is not quite well-reasoned.	The solution is messy and not structured. There are no criteria for the analysis.	The solution is illogical, without a clear structure.
Breadth of analysis	All aspects of the problem are analyzed. The most important aspects are highlighted (priority scales). The choice of priorities is supported with the analysis of facts and data. All financial matters, risks, further plan of actions are highlighted. There is comprehensive understanding of the task.	All aspects of the problem are analyzed. Not all important aspects are highlighted (priority scales), though the choice of priorities is supported with the analysis of facts and data. All financial matters, risks, further plan of actions are outlined. There is comprehensive understanding of the task.	Not all aspects of the problem are analyzed. There is no priority scale. Financial matters, risks, further plan of actions are not quite outlined. There is no comprehensive understanding of the task.	The analysis is not broad.

Table 1 (continued)

Criterion	Assessment and description			
Group 1 The ability to work with information and analytical skills (hard skills)	4-5 points	2-3 points	1 point	0 point
Depth of analysis	The solution is clear and well-reasoned financially and economically. All data and facts are supported with calculations and references. Some optional solutions are considered.	The answer is not full, but the solution is clear and well-reasoned financially and economically. Most data and facts are supported with calculations and references. Some optional solutions are considered.	The solution is clear, though not quite reasoned financially and economically. Figures and facts are not supported with calculations and references. Only one alternative solution is considered.	The solution is not clear and not feasible financially and economically.
Performance of the solution	The solution is technologically feasible; the best use of modern technologies and innovative ideas is made.	The solution is technologically feasible; not all modern technologies are described when solving the problem.	Outdated technologies are used.	Feasibility of the solution is not demonstrated.
Group 2 Interaction and cooperation (soft skills)	4-5 points	2-3 points	1 point	0 point
Presentation of solution	Business-like color spectrum and unified design style are used, the slides are arranged logically, there are no misprints.	Business-like color spectrum and unified design style are used, the slides are not quite logically arranged, there are no misprints.	Business-like color spectrum and unified design style are used, the slides are not arranged logically, there are misprints.	The presentation is not made.

Table 1 (bottom)

Criterion	Assessment and description			
Group 2 Interaction and cooperation (soft skills)	4-5 points	2-3 points	1 point	0 point
Answering questions	Students eagerly answer the questions, know all aspects of the solution well (do not sight read, do not stumble), are confident and enthusiastic, keep an eye-contact with the audience.	Students eagerly answer the questions, know all aspects of the solution quite well.	Students hesitate answering the questions, sight read, stumble, and falter.	Students cannot answer the questions, cannot explain the solution, and hesitate.
Team work	All team members can express their opinion, roles and areas of responsibility are clearly defined. Team members support each other, when the situation is challenging, some team members do not differentiate themselves from others, do not contradict and do not argue with each other, add to each other's answers.	All team members can express their opinion, roles and areas of responsibility are clearly defined. Team members support each other when the situation is challenging, some members differentiate themselves from others, contradict, but do not argue with each other.	All team members can express their opinion, roles and areas of responsibility are not defined. Team members do not support each other, but contradict and argue.	Only the team leader can express his opinion.

1.7. Recommendations for students

1.7.1. Assemble an efficient team

Roles in a team

There are four roles in a team:

a) a leader provides guidance, supervises the team work and task performance, designs the structure of the solution;

b) a slide-maker generates new creative ideas, makes a presentation;

c) a financial expert makes calculations, designs mathematical models;

d) an analyst searches quality information, investigates certain tasks, improves the presentation.

The roles in a team can be combined and doubled.

Types of the teams

There are three types of efficient teams: a team with clearly differentiated responsibilities, «two by two» and «one man army».

In a team with clearly differentiated responsibilities every student performs one function. The roles often differentiate naturally. However, if a slide-maker would make calculations, an analyst would correct the presentation, a financial expert would try to find mistakes, while the leader would do nothing, the team is sure to fail.

In a team «two by two» the team members are universal players, since everyone can perform, at least, two functions. For instance, two analytic-financiers and two creative leaders. The benefits of such team are a back-up player for every role.

In a «one man army» team there are four leaders with great analytical thinking and attention to details. In this case all members are involved in the process, can back up each other and are good at time-management and task performance.

Keeping balance between unity and diversity

At the core of an efficient team is the unity of aspirations and values. If to compare it with a business process, we can say that the team leader is a top manager who develops the management strategy. Team members must share the business philosophy and have the same level of language expertise. If some team players speak the language of a case study fluently, and the rest can only read and translate with a dictionary, it will be too time-consuming to overcome the language barrier.

An advantage is when every team player focuses on a certain aspect of the problem. The differences between team players are also beneficial, since they contribute to personal development. In the course of decision making team members will share their experience and knowledge.

How to build a team

To become efficient a team must go through four stages: forming, storming, norming and performing.

a) at a **forming** stage the team members define the goals, means to an end and their roles in the team;

b) at a **storming** stage team members fight for leadership and contest for influence. This stage is important to discover the existing differences. When the conflicts are settled, the relations in the team become strong and trusting;

c) a **norming** stage – is a period when team players work out the organizational principles of their future work and establish cooperation.

d) a **performing** stage – is a work process, when 100 % of the time is devoted to solving the case study.

The leader should remember that:

- the most efficient team is that of like-minded people. It is better to solve large intelligent problems with people who really share your interests and are ready to work for the benefit of the team;
- invite, at least, two people, who have already worked together, as they have responsibility to each other;

a) make a plan to work on a case study;

b) remember that all team members are equal, everyone has a right to suggest his variant solution;

c) consult with other team members;

d) delegate the tasks, otherwise you will not manage the whole amount of work;

e) do not object, if somebody decides to assume a position of a coordinator;

f) take initiative only in challenging situations;

g) encourage others' initiative.

1.7.2. Recommendations for a case study analysis

a) read carefully the case study and questions to it, make sure that you understand the task well;

b) highlight important information and note that 30 % of the solution can be elicited from the case study itself;

c) read the text again and highlight the points (facts), related to the questions;

d) find, what ideas and concepts are related to the problem;

e) using the text, shape the problem description into a sequence of tasks;

f) in the core units of special subjects find the key ideas to foreground the knowledge to be used when solving the case study;

g) outline the structure of the solution and methodology of analysis, define the areas of responsibility.

h) start off doing the case assignments, getting ready for working out your solution option;

i) suggest a possible solution: objective, logical, consistent, well-reasoned, supported with facts.

j) work in parallel, collecting information and analyzing it in steps. When some parts of the solution are ready, put them on the slides and send to the team member responsible for making the final presentation.

k) combine the odd parts, make a clear decision, make conclusions, and structure everything.

1.7.3. Make a quality presentation

a) in the introduction provide general information: describe the problem, specify what question you are going to address; make an Executive Summary: highlight the final conclusions of the solution. It will help structure the main body of the presentation and show your respect to the audience;

b) in the main body of your presentation consistently clarify all aspects of your solution, explain your actions and give reasons for your choice. Make conclusions on every aspect;

c) make precise headlines;

d) read the headlines in succession. Ideally they must present a logical and consistent story about solving the case study and generating the conclusion. It can be easily checked: when you make the final presentation, switch to Slide Sorter view and revise the presentation. You will see if some slides are not in line with the general visual and must be corrected;

e) make your slides attractive and neat. Use a unified color scheme, e.g., corporate colors of your university. The universal rule is to use not more than three different hues. Use a color wheel to find color harmonies, make the images hard to look and note that the slides must be stylish;

f) create a unified design for all slides and take note that all makeup elements are in their places;

g) add quality images. They must be supportive, not distracting from the message. Use simple one-color icons;

h) flow charts and diagrams must be distinguishable, flat and clear;

i) add something special to the presentation, e.g., use video in the introduction;

j) review the solution and make sure that all figures are correct and there are no misprints. If necessary, improve it.

k) mind that creativity must be beneficial and powerful.

1.8. Case 1. Digital development prospects of the Far East

Introduction

It is an educational case which is based on real data. However, due to confidentiality concerns some parameters, values and data were simulated. The solution must be based on the information given in the case. To avoid errors it is recommended not to draw an analogy with similar real life situation and not to use unconfirmed information. Note that a case can have alternative solutions, none of which can prove to be totally correct or incorrect. Of prime importance are technical competence, decision logic, presentation design and performance.

1.8.1. Key aspects

The Far East projects realization depends on the staff expertise and on advanced technology solutions, ensuring efficiency rise. Priority of communication technologies, creation of production cycles in the remote areas, large-scale relocation of skilled staff call for a combined approach to the digital transformation.

All energy projects on the Far East are implemented under digitalization of economics of the countries in the Asia-Pacific region. Therefore, the Far East becomes a driver of digital transformation in the energy sector.

Development prospects of the Far East are closely connected with its competitive advantages over other regions in Russia:

a) Geographic proximity to the large markets of the Asia-Pacific countries – China, South Korea, Vietnam. These countries are noted for sustainable economic growth;

b) Availability of natural resources: coal, oil, gas, iron, non-ferrous metals, timber;

c) Developed port infrastructure.

d) It provides opportunities for useful exploitation of the Far East territories.

e) The main trading partners of the Far East are Republic of Korea and China.

f) The key projects of the fuel and energy sector on the Far East are:

g) Amur Gas Processing Plant. The gas reserves are developed by PAO «Gazprom». The largest producing fields on Sakhalin account for generation of 11,5 million tons of liquefied natural gas. The export share is 3,3 million tons, of which to Japan – 38%, China – 18%, Taiwan – 12%, South Korea – 8%.

The existing gas pipelines with a total length of 1,8 thousand km enable gas transportation from Sakhalin deposits only to the Khabarovsk Territory and to the south of Primorsky Krai.

«Power of Siberia» gas pipeline with a total length of about 3 thousand km connects the Amur region with the deposits in Yakutia and the Irkutsk region, and will also enable gas transportation across Amur River. For processing gas transported via «Power of Siberia» Amur gas processing plant (Amur GPP) is being constructed in Primorsky Krai. It will be the largest in Russia and will take the second place, with regard to the capacity factor, gas processing plant in the world. When the production is launched, up to 1,5 million tons of propane and butane a year and up to 60 million co m. of helium a year will be supplied to the Asia-Pacific countries.

a) Beringpromugol: development and recovery of coaking coal on the Amaam deposit;
b) Sibneft-Chukotka: a construction project of a network of gas pipelines in Chukotka;
c) Nord Energy: re-equipment of power facilities;
d) a natural gas liquefaction plant on Sakhalin.

According to the strategy development of the energy sector, gas recovery in the Far East will increase almost 2,5 times, oil recovery – 70%. Thus, development prospects are mainly attributed to the construction of energy processing and transportation units.

1.8.2. Digital solutions in industry energy production

Application of digital technologies enables increasing productivity of enterprises, and cost improvement. Digitalization of the operational processes not only helps to increase productivity but also boost security and energy efficiency.

- Digital technologies:
- Big Data: analysis of large volumes of structured and non-structured data;
- IoT (Internet of Things): connecting smart-sensors, devices and equipment to the network;
- Mobile devices: combination of networks, devices and software allowing to be on-line and manage the process anytime;
- Cloud storage of data: continuous access to the necessary programs and data from anywhere globally;
- Automation and robotics: autonomous operation of hardware and software robots or their collaboration with people; implementation of a hybrid workforce type (man + machine);

- Artificial Intelligence (AI): smart machines assist people in solving problems and make independent decisions;
- Platforms, special applications for interaction and team work;
- Wearable technologies (WT): combine the sensors functional, software and capabilities of connection to the network for tracking and data exchange;
- Creatinge «digital twins». A digital twin is defined as a virtual replica of a living physical entity or a system during their lifecycle using real-time smart sensors data. In the digital twins technology a mathematical model for a physical entity, a piece of equipment or the whole process is developed, which is used to analyze the object behavior. The digital model is continuously updated to fully conform to the current working condition of the real machine. It enables identifying unexpected variations in the processes; improve equipment performance, prevent faults and accidents, which will significantly enhance reliability and operating efficiency. According to *Eutech Cybernetics* companies can reduce expenditures more than 30%, if they switch to intelligent operation and control. In oil and gas industry a digital twin technology is used for creating digital (smart, intelligent) fields. A digital field is an expert-analytical system which quickly collects, analyzes information and provides recommendations on operational excellence of petroleum refinery. The power generating industry implements digital power stations projects (a digital twin of a real power station, integrating some objects into a system). *GE Power* presented the concept of a digital thermal power-station – the complex of digital solutions, which will help to significantly reduce greenhouse gases emissions due to efficiency upgrading of coal-steam plants.

The digital solutions, such as artificial intelligence (AI), computer-aided learning, IoT, blockchain and Big data, allow decreasing losses when the energy is transported from the generation source to the consumer, improve safety and reliability of energy supply, efficiently redirect power flows, reduce the working cost of energy resources and production processes.

A smart grid is an intelligent network. The basic engineering element of a “smart” or digital grid is an intelligent system of electric power metering. In power industry the system is used to quickly and efficiently identify the accurate scope of services, make multi-rate electricity calculation, and monitor electric power quality. The sources of primary information in the grid, in this case, are Internet of Things, i.e. networked smart meters and sensors. The smart grid system is implemented at all levels of the power system – from generation to service and consumption and combines advanced IT and energy technologies: metering equipment, automated control systems components of substations, distributed power banks; automatic distribution; power generation forecasting. An important element of a digital network is self-repairing technologies. They make it possible to check the system for problems and isolate the damaged areas and components of the system. Implementation of intelligent technologies of a smart grid will enable significantly enhance reliability and quality of power supply, utilization efficiency of primary energy sources, keep down the costs of industrial processes and environmental footprint.

1.8.3. Economic effectiveness criteria for the integration projects assessment

Currently a number of criteria for project assessment have been developed internationally. The analysis techniques can be conveniently classified into two groups.

1st group. Statistical (simple) methods: based on accounting estimates and do not take into account the time element. The money flows, appearing at different times are viewed as identical. The effectiveness criteria are payout period (PP) and accounting rate of return (ARR).

2nd group. Dynamic (discounted) methods: based on discounted values with account taken of the time element. Discounting enables unifying the money flows, providing compatibility of projects occurring at different times. The effectiveness criteria are net present value (NPV), profitability index (PI), internal rate of return (IRR), modified internal rate of return (MIRR), discounted payback period (DPP).

For primary analysis and project ranking statistical methods are used. For developing medium-term and long-term projects provision must be made for changes in values of financial assets with the time. Therefore, the use of dynamic methods seems to be the most efficient.

1.8.4. Initial data

Project 1. Advanced development zone «Petrochemical» (figure 1.1).

Figure 1.1 Advanced development zone «Petrochemical»

Location: Primorsky Krai.

Basic industries: hydrocarbons processing, oil and natural gas conversion, chemical industry.

The Eastern oil and gas complex became the first resident of the advanced development zone «Petrochemical». It is planned to implement an investment project aimed at launching a complex of petroleum refineries and petrochemical production of motor fuel, not lower than the classified grade Euro 5, petrochemical production of a broad brand assortment of polymers (polyethylene and polypropylene) and medical products.

The project will contribute to the creation of oil and gas cluster and in the long run will satisfy the demand for petrochemicals in the region and on the Asia-Pacific markets. The project will facilitate the Far East development due to additional investment into the local infrastructure, new jobs creation, and increase in budget revenue by means of additional tax collection.

The throughput would amount to 30 million tons of oil annually; the investment amount will be 600 billion roubles. The construction costs of the Eastern oil and gas complex are 1,3 trillion roubles.

Project 2. Advanced development zone «Priamurskaya» (figure 1.2)

Figure 1.2 Advanced development zone «Priamurskaya»

Location: Amur Oblast of the Far Eastern Federal District.

The zone is created to foster production cooperation between the Russian Federation and People's Republic of China. The competitive advantage of Amur Oblast is its location: the region has a common border with China, where there are three international crossing points; trade and economic cooperation with China accounts for 80-95% of the region value of foreign trade.

Basic industries: logistic business and industry.

Resident-company: Amur Energy construction of a petroleum refinery. The initial investment amount is 2 052 million dollars.

Competitive strengths: high quality and the amount of raw materials, which estimated potential reserves, are at 400 billion dollars. Amur Oblast accounts for three thirds of the Far East hydropower resources, and coal reserves are far larger than the ultimate reserves of the Khabarovsk Territory, the Chita Region, Sakhalin and Primorye. All these advantages open up great opportunities for development.

Project 3. Advanced development zone «Svobodny» (figure 1.3)

Figure 1.3 Advanced development zone «Svobodny»

Location: Svobodny town, Svobodny and Skovorodinsky Districts of Amur Oblast.

Basic industry: petrochemical industry.

Competitive strengths: sufficient energy resources for hydrocarbons processing; proximity of operating oil and gas pipelines; availability of oil and gas transportation infrastructure.

Resident-companies:

- Technoleasing: launch of methane production in Skovorodino town of Amur Oblast and re-equipment of processing facility and steam cleaning of truck vans;
- Gazprom Pererabotka Blagoveshchensk: Amur Gas Processing Plant. The plant will have six production lines with capacity of 7 billion cubic meters of gas per year each. In the first year two production lines will be commissioned, the other production lines will be commissioned in succession within four years. Therefore, in five years the plant is planned to achieve the design rated full power;
- Sibur holding: Amur Gas Chemical Complex. Execution period – seven years. Investment amount – 555 219 million roubles;
- Construction of the main gas pipeline «Power of Siberia».

1.8.5. Questions to solve the case

a) Choose the most promising, to your mind, energy project in view of the advanced development zones;

b) Specify a list of digital solutions in view of the chosen project;

c) Substantiate the digital solutions on safety of production processes and economic efficiency.

1.9. Case 2. Development of Wide Area Measurement Systems

Introduction

Wide Area Measurement Systems (WAMS) development was determined by the necessity to have a data source, giving an accurate picture of dynamic behavior of power systems in case of technological disturbances and accidents.

The existing remote control systems transmit data to dispatching control rooms and power system control centers 3-10 times per minute. That sort of information quality prevents defining and registering dynamic characteristics of equipment and load buses in the algorithms of monitoring and control systems, which limits opportunities for their development.

Technical improvement of the modern monitoring and control systems is essential due to adoption of renewable sources of energy and FACTS technologies development.

In the circumstances one of the solutions must be synchronized phasor measurements as a source of information for monitoring and control systems. Phasor measurement of power regime parameters is highly promising to upgrade power systems control.

Today WAMS recorders are installed at high-voltage power networks facilities, which allow obtaining complete and accurate information on basic parameters of the power system, analyzing the ongoing events and examining dynamics of the power system.

1.9.1. Glossary

Accidental allowable active power flow: the maximum value of the allowed active power flow in the controlled cross-section under the forced mode.

Interconnection: a sequence of elements connecting two parts of a power system. Apart from transmission lines the sequence can include transformers, bus bars, switching devices, considered as network units.

Controlled cross-section: the total of transmission lines and other elements of an electrical network defined by the operational-dispatching office of the entity. Their active power overflow is controlled and/or regulated to provide stability of power system and permissible operation of transmission lines and equipment.

Maximum allowable active power (MAAP): the maximum value of the allowed active power flow in the controlled cross-section under normal operating conditions.

Synchronized phasor measurements (SPM**):** a set of vector and scalar parameters of the electrical power regime, measured and calculated in the given range, with the assigned sampling at certain time points, synchronized with global navigation satellite systems.

Global Navigation Satellite System (GLONASS): a space-based satellite navigation, made up of satellites used in a network and transmitting a synchronized time signal with assigned sampling and accuracy.

Phasor Measurement Unit (PMU): a device (a feature of a multifunction device), used for measurement, processing and calculation of vector and scalar parameters of electrical regime.

Phasor Data Concentrator (PDC): a software and hardware device (or a feature of a multifunction device), used for receiving, processing, storage and transmission of synchronized vector measurements, analog and discrete data.

Software and hardware complex of a Wide Area Measurement System: a set of devices and their software installed at a power facility, which is used for measuring, processing and transmitting synchronized vector measurements, analog and discrete data to the dispatching offices.

Automatic information acquisition system (AIAS) of WAMS recorders: an automatic system installed at dispatching offices, which provides on-line and off-line collection of synchronized vector measurements, analog and discrete data, their processing and transmission to the automated monitoring and control systems and automatic control system.

Wide Area Measurement Systems (WAMS): a set of WAMS software and hardware complex and computing complexes, used as data support for operational dispatch management and automated control of power system regimes.

Power system control center: a structural division of an operational-dispatching office entity, which controls the power system regime in the assigned operational zone.

1.9.2. WAMS technology

1.9.2.1. General information

The technology is based on measuring the system state variables in energy hubs with a frequency of up to 1000 measurements in the supply network frequency period (50 000 measurements per second), with data transfer of 50 times per second (figure 1.4).

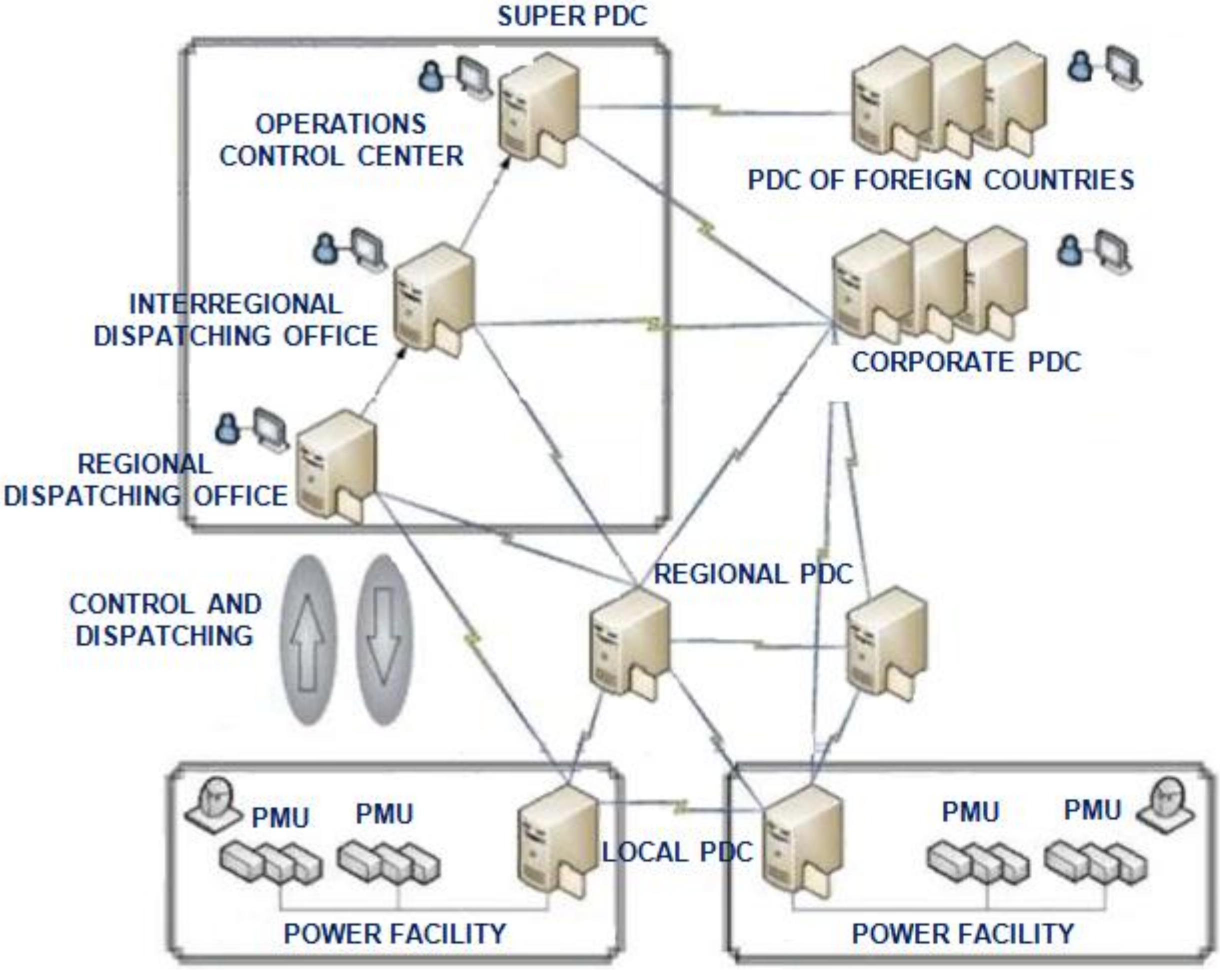


Figure 1.4 Data collection and transmission to WAMS

The measurements transmitted to the dispatching office are time-synchronized with the satellite navigation systems with an accuracy not exceeding $1*10^{-6}$ seconds. Due to the development and creation of SPM, we can obtain accurate system state variables and form basis for improving the automated system operation algorithms, power system protection and control on the modern data platform.

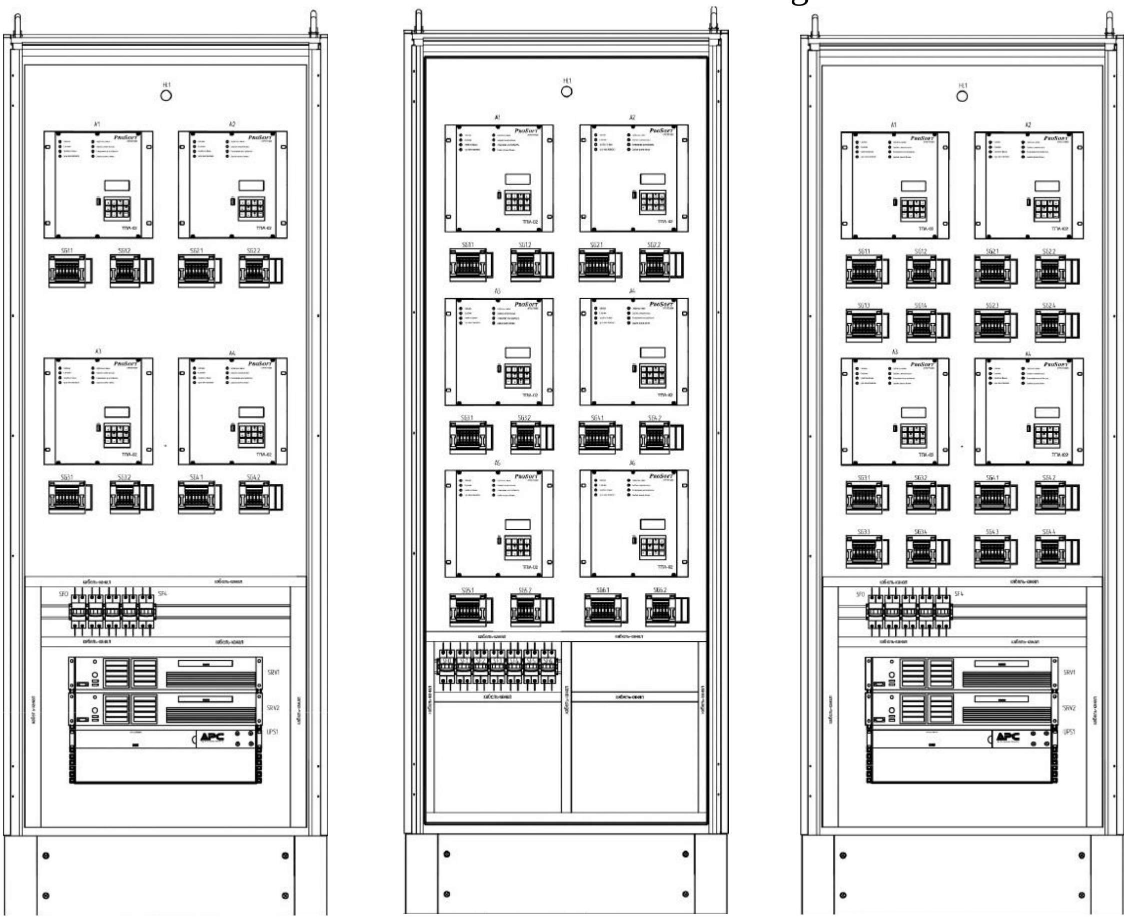
The advantage of the vector measurement technology over the traditional one is continuous parameter vector recording in transient and steady-state regimes.

1.9.2.2. WAMS manufacturer

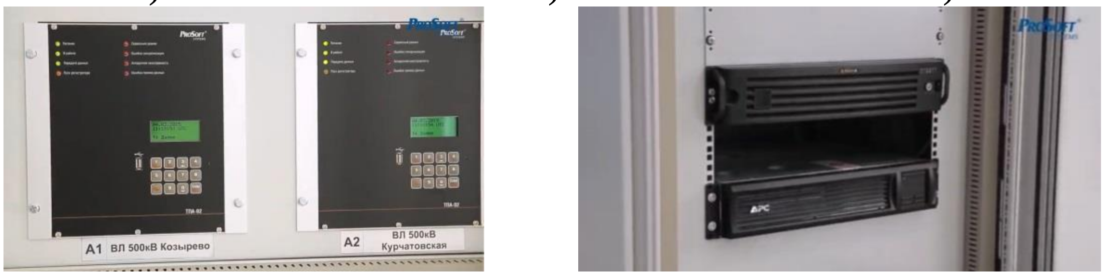
Arbiter Systems Inc. designs, manufactures and distributes precise time and power measurement solutions to electrical utilities worldwide. Enabling tomorrow's technology today, Arbiter products are found in the most complex, mission critical environments where reliability and accuracy are paramount, including the measurement and analysis of synchrophasors.

1.9.2.3. Patterns

PMU and PDC are mounted in separate base cabinets in relay rooms and substation control buildings (SCB) at power stations and substations. The cabinet has a glass door in front and a solid steel door in the back. The PMU cabinet exterior dimensions are 2000×806×600 mm, a PDC cabinet – 2100×606×600 mm. The view of the cabinets is in figure 1.5.



a) b) c)



d) e)

Figure 1.5 WAMS cabinets: a) 4 PMUs with PDC; b) 6 PMUs without PDC; c) 8 PMUs with PDC; d) PMU in a WAMS cabinet; e) PDC in a WAMS cabinet

1.9.2.4. Software and hardware complex

A comprehensive solution for WAMS is based on software and hardware complex. It includes PMU, a tester for generator excitation system (PMU) and PDC. Software and hardware components are time-synchronized with GPS/GLONASS receivers, embedded in the software and hardware complex.

PMU is used for measuring phasor current and voltage and subsequent transmission to PDC specified by the information protocol.

PMU core functions: current and voltage measurement of the controlled network, current angle calculation (phase-by-phase), line frequency calculation, calculation of line frequency rate change, current and voltage measurement of the generator excitation system, a recorder time synchronization with GLONASS/GPS standard time signals, data transmission specified by the information protocol.

PMU additional functions: sequence-of-events recording, emergency alarm system, self-diagnostic, embedded web-interface.

A time synchronizer is a compact device, aimed at solving time synchronization tasks, without the support of network time protocols. It is used to receive signals from the global navigation satellite systems GLONASS and GPS, to generate standard time signals in 1PPS, IRIG-B, IEEE 1344, IRIG-B, IEEE 1344, 10 MHz formats, to indicate the operation mode and for self-diagnostic; to reduce the time for satellite search and setting synchronization; if the device is fixed program configuration is performed. UTC offset limits in the «Stable synchronization» operation mode are $\pm 200 \cdot 10^{-9}$ sec.

A Book of Typicals and a design guidance for the software and hardware complex, including stages, a block scheme, classification, specifications of the installed equipment, cabinet assembly, measuring circuits of current (CT) and voltage transformers (VT), data links arrangement, UTC support system and the input list of data, transmitted to the operational control center, can be accessed by the link:
http://www.prosoftsystems.ru/uploads/public/files/Documents/RZA/ATR_RZA_V1.3_150926.pdf.

There are special WAMS requirements concerning equipping electric power facilities with PMU and a software and hardware complex.

According to these requirements a software and hardware complex must be installed at:

a) Power stations with the installed capacity of 500 MW and more, as well as power stations and substations with electrical switchgear of the highest voltage rating of 330 kV and above. In this case PMU is installed at the next connections: 330 kV and above transmission lines; 220 kV and above transmission lines in the controlled cross-section; 220 kV and above interstate transmission lines; autotransformers in the controlled cross-section (from the primary voltage side); 200 MW and above turbo-generators at nuclear power stations and heat power plants; 100 MW and above hydrogenerators at hydropower stations and pumped storage power stations (PSPS); 60 MW and above generators in combined cycle gas turbines.

b) Power facilities with 220 kV electrical switchgear of the highest voltage rating. In this case PMU must be installed at the next connections: transmission lines in 220 kV controlled cross-section; 220 kV interstate transmission lines.

c) Installation of a software and hardware complex at other power facilities can be provided by the design documents on the facility building, reconstruction and renovation to ensure reliability of power system operation. If according to the established criteria it is necessary to install PMU at a power facility on no more than two connections, then self-contained PMU can be installed.

1.9.2.5. PMU specifications

PMU is used for accurate measurement of synchronized vectors of phase current and voltage, frequency, rate of change of frequency and transfer of the measured parameters to PDC. PMU is a measurement component of a power facility software and hardware complex or a self-contained unit. PMU must perform the next functions: SPM measurement with permissible errors in static and dynamic conditions; synchronization with global navigation systems; making a SPM slide at each time interval; SPM transmission according to the international protocol; on every SPM slide there must be UTC timestamp.

PMU must measure:

- Synchronized vectors of phase voltage, where the magnitude is the effective value of the first harmonic of phase voltage (Ua, Ub, Uc), and a phase angle is a corresponding absolute voltage angle (δUa, δUb, δUc);
- Synchronized vectors of phase current, where the magnitude is the effective value of the first harmonic of phase current (Ia, Ib, Ic), and a phase angle is a corresponding absolute current angle (δIa, δIb, δIc);
- Frequency (phase-by-phase and positive sequence (fa, fb, fc, fU1);
- Rate of change of frequency (dfa/dt, dfb/dt, dfc/dt).

When necessary, generator excitation values must be measured at the interval, equal to the utility frequency period. The measurements are:

- Field voltage (rotor voltage) (Uf);
- Generator excitation current (rotor current) (If);
- Excitation voltage (Uf);

- Excitation current (If).

An ultimate solution is to collect on-line SPM from all recorders with the maximum sampling and store them on the servers. However, it is hard to realize due to large amounts of information and the shortage of wideband channels.

1.9.2.6. WAMS applications

Increase of WAMS software and hardware complexes put into operation at power facilities enables significantly increase visibility and quality of disturbances analysis, assess validity of operation of protection relay and automation and find violations of operating conditions of equipment.

SPM is used to investigate accidents and power system disturbances, to verify calculation models, to calculate dynamic behavior of power systems, to check the system regulators for correct operation, to monitor Low Frequency Oscillation (LFO). Besides, SPM is used to calculate the maximum allowed power flows and identify critical sections of a power system.

a) WAMS software and hardware complex was installed at a State District Power Plant (SDPP) when constructing a new 660 MW coal-based generating unit. Commissioning of a new electrical generating unit enabled increasing the HPP capacity up to 3000 MW. The installed capacity is 1315 MW. Under the project 7 WAMS cabinets were mounted. WAMS complex solution includes: PMU, time synchronizer and PMU recording of generator excitation values. WAMS software and hardware complex tests operating parameters of four turbine generators, of all 500 kV outgoing OHL, interstate transmission lines and transmission line interconnections of all voltage ratings. Among other monitored connections is the auto-transformer high-voltage winding. WAMS software and hardware complex also measures current and voltage values of a generator excitation winding. All SPM are transmitted to the dispatching office.

b) Verification of calculation dynamic models is an important operation to check accuracy of simulation of electromechanical transient states and transient stability calculations. Verification of a dynamic model is comparison of transient state parameters, registered in a real system with a WAMS recorder with similar calculated parameters, obtained during EuroStag or Rustab calculation of a transient state with a similar excitation. To verify the dynamic model, four main subtasks can be highlighted: verification of a steady-state mode model; verification of data on power equipment characteristics and parameters; verification of data on characteristics and adjustments of regulation and control units; verification of the entire dynamic model.

Regular verification and updating of a dynamic model allows using it as a reference model, which can help create and update dynamic models of certain interconnected systems.

c) Analysis of a generator automatic excitation control. Numerous short circuits in B phase of a generator (the first short circuit occurred at the bushing of a step-up transformer) were recorded at a State District Power Plant: displacement of a central point in the circuits of generation voltage and operation of AEC (automatic excitation control) excitation forcing, which caused active power oscillations ranging from 250 to 500 MW. In this case, ground fault current in the stator winding was less than 5A setting. Thus, the fault was not fixed. Before the generator dropping, over 400 short circuits were recorded. After that the generator was shut off with the stator winding ground-fault protection 1 hour 12 minutes after the first short circuit. The power plant personnel did not take any actions until the generator of relay protection was shut off. As a result, the generator was taken out of service for repair for a day by request.

d) Separate network operation. A few synchronized oscillations of active power were registered in one controlled cross-section. One of them caused switching to separate network operation by out-of-step conditions liquidation automation. After the short circuits near the power plant, some transmission lines were taken out of service. It caused divergent active power oscillations in the controlled cross-section from 300–710 MW range to 140–800 MW range. The synchronized oscillations lasted for 110 seconds. The results of analysis and frequency change oscillogram showed inadequate operation of system regulators of generators in terms of oscillations damping. As a result, the automatic excitation control (AEC) of the plant generators was replaced.

e) LFO analysis. At a 500 kV substation the next mode of LFO parameters of electric regime was recorded: 0,47 hz frequency, 7 MW active power magnitude, 6 MHz frequency and low level of damping (70 seconds). To explore the reasons for LFO the generators operation was analyzed. It was determined that the sharp decrease of damping mode level occurs during operation of a certain hydropower plant unit in the 100–320 MW range. Considering the analysis of the reasons for LFO development the power plant personnel together with the generator factory tested the hydropower unit and updated its specifications. LFO monitoring is common and regular in large power systems, since one of the worst consequences of weakly damped LFOs is disturbance of oscillatory stability of the power system resulting in system emergency. LFO is analyzed to solve the next tasks, ranging from LFO identification, monitoring of the oscillatory stability of the power systems, verification of digital models of the power systems using mode characteristics to adaptive control of the power systems operation. It is done to increase damping characteristics through configuration of regulation characteristics of automatic excitation control of synchronous generators of power plants, phasor measurement of voltage and current. Research is being done on realization of automatic on-line LFO monitoring to identify the most dangerous oscillation zones in time, to provide comprehensive visual information about the actual LFO parameters and to run static analysis on the change of modal characteristics of the power system. The basic principle of LFO automatic monitoring is continuous monitoring of spectral properties of operation parameters both in normal and emergency operating conditions of the power system. The data source for the LFO automatic monitoring is WAMS automatic information acquisition system, providing collection of synchronized vector measurements from power facilities and their efficient transmission to dispatching offices with low delay.

1.9.3. Integrated power system of the East and electric power system of the Sakha Republic

Integrated power system of the East is located in the Far Eastern Federal District and four territorial entities: Amur Oblast, Primorsk Krai, Khabarovsk Krai, Jewish Autonomous Region and the Sakha Republic.

The Bulk Electricity System includes four regional electric power systems: Amurskaya, Primorskaya, Khabarovskaya and Yakutskaya. Khabarovsk power system includes Khabarovsk Krai and Jewish Autonomous Region (figure 1.6).

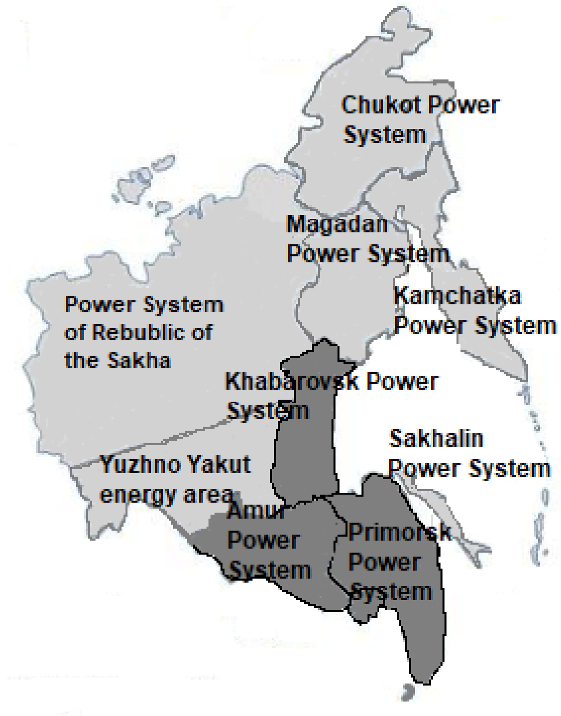


Figure 1.6 – Interconnected Power System of the East

For geographical and technological reasons the electric power system operates independently from the Unified Energy System (UES). On the territory of Khabarovsk Krai there is Nikolaevsk energy area, which operates separately from the UES of the East.

The UES of the East is asynchronously connected by three 220 kV high-voltage electric transmission lines with the UES of Siberia and borders with the electric power system of China. Most generating plants are heat power plants with a limited controlled range. The major generation sources are located in the western part of the UES, while the major consumption areas are in the south-east. Therefore, the transmission lines are long.

Another feature of the UES of the East is high share of public utility load in the total energy consumption – about 25%.

The UES of the East consists of twenty seven 5 MW and above power plants with 11 264,7 MW of gross installed capacity, electrical substations of 110–500 kV voltage rating and 38,8 mln. kVA of total transformer capacity and 110–500 kV transmission lines of 33 025 km of total length.

Electrical generation over a year accounted for 37 645 million кWh, while energy consumption was 34 197 million кWh.

The UES electric power systems are controlled by four Regional Dispatching Offices (RDO): Amur, Primorsk, Khabarovsk and Yakut.

Amur RDO operational zone is the electric power system of Amur Oblast and Yuzhno-Yakut energy area, including Aldansky and Neryungrinsky districts of the Sakha Republic.

Khabarovsk RDO operational zone includes the electric power system of Khabarovsk Krai and Jewish Autonomous Region.

Yakut RDO operational zone includes Central and Eastern energy areas of the Sakha Republic. Yakut RDO is in the operational zone of Interregional Dispatching Office of the East and performs dispatching control of power facilities in Western and Central energy areas of the Sakha Republic electric power system. In the operational zone there are power generation facilities of 1 623,7 MW rated output power. The largest ones are a series of Vilyujsky HPPs, Svetlinskaya HPP, Yakutskaya SDPP (figure 1.7).

The power sector of the region includes 110-220 кV transmission lines 7821 km long, transformer substations with 3 232 MVA of total transformer capacity. The total rated output power of the substations of the electric power system of the Sakha Republic is 2 506,7 MW per year, annual electricity consumption – over 6,5 bln. kWh, maximum energy consumption is assessed as up to 600 MW.

Figure1.7 – Central and Western districts of the Sakha Republic: CHPP – Combined Heat and Power Plant; HPP – Hydro Power Plant; SDPP – State District Power Plant

1.9.4. Synchronization of Western and Central energy areas of the Sakha Republic with the UES of the East

Synchronization of Western and Central energy areas of the Sakha Republic with the UES of the East requires their synchronous operation at the same electrical frequency. This implies the universal dispatching control strategy and technical policy in the interconnected energy areas.

Connection of the Central and Western energy areas of the Sakha Republic initially was not considered. Feasibility of a large-scale project of the kind had not been done before. Operation of both energy areas was balanced: the areas had excessive generation and gas reserves, the rated output power of generation facilities covered the current consumption, and an increase of the commercial demand was not forecasted. The situation changed with the construction of Eastern Siberia – Pacific Ocean oil pipeline. Realization of the project facilitated construction of the grid infrastructure for the substations supplying energy to the oil booster stations. The 220 кV transmission lines under construction could be also used for interconnected operation with the UES of the East. The consumers could benefit from significant improvement of security of supply: despite excessive generation, the scheme and regime event was arranged in such a way that even single isolation of generation or transmission facilities during the high load often caused disconnections. Eleven cases were recorded when from 12 to 90 thousand people were left without power.

To connect the energy areas two 220 кV transmission lines were constructed: Nizhnij Kuranakh – Tommot – Maya 482,05 km long; Nizhny Kuranakh – OPS15 – Olekminsk 410,5 km long. During the course of tests stable interconnection synchronous operation of the Western energy area with the UES of the East was ensured (figure 1.8).

Figure1.8 – Sketch map of 220 кV transmission lines: OPS – oil pumping station

The set tasks are:

a) The technical project for updating the system of telemetering data exchange of Viluisk HPPs is being developed. Currently, this system of Viluisk HPP cascade partly meets the requirements: the collected telemetering data necessary to control the facility is not complete.

b) Commissioning of the automatic load-frequency control system is projected. As a result, the flows will be automatically regulated. Now dispatchers give commands to execute operative secondary control.

c) Commissioning of automatic overfrequency protection is projected, which will also contribute to improving customer power supply.

d) An important task is adjustment of the automatic control system of hydropower units of Svetlinskaya HPP to ensure primary frequency regulation to maintain electric power supply of consumers and operation of power stations in case of significant frequency deviations.

1.9.4. Questions to solve the case

1. Suggest and explain installation of additional PMUs at the UES of the East power facilities after interconnection of Western and Central energy areas of the electric power system of the Sakha Republic.
2. Make and base a PMU project implementation schedule.
3. Show the ways to use WAMS to improve the quality of regime control of the UES of the East.

Unit 2. Business games in power engineering

Introduction

To increase students' interest in the subject matter, to make it practice-oriented, active teaching methods are used, including business games [6-8].

To be used for academic purposes a business game must meet the next principles: clarity, involvement, comprehensibility, and connection between theory and practice.

A business game is a tool to simulate professional activity, to imitate the working process, to reconstruct real working conditions in a simple way. The use of real power facilities schemes enables bringing learning to practice as much as possible.

Students are given the tasks similar to those they will encounter in their future professional activity, for example:

- control of power equipment operation (operational switching);
- control of power facilities modes: normal, maintenance, and emergency.
- A business game focuses on two types of activity: play-based and academic.
- Professional activity is performed as a game. The academic task is to gain knowledge and develop skills.
- The common algorithm for creating business games involves the next stages:
- defining goals and tasks;
- specifying technical facilities;
- defining participants' roles;
- description of the object's initial condition and a problem-based situation.

Business game rules are similar to the staff training guidelines at power facilities.

The participants' assessment includes a list of the actions assessed and grades, added or subtracted for every operation.

2.1. Business game 1. Operational switching

Glossary:

A **circuit breaker** is a switching device, capable of making, carrying and breaking currents under normal circuit conditions, and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of a short circuit.

A **disconnector** is defined as a mechanical switching device which provides, in the open position, a specified isolating distance. It should be capable of opening and closing a circuit when negligible current is broken or made.

A **grounding switcher** is applied for protection of equipment when the cost of supplying other protective equipment is deemed unjustifiable.

Description: The substation is fed by 110 kV overhead power line C-76 and has two 110 kV outgoing lines, C-81 and C-82, connected by two 110 kV bus sections and a maintenance bypass junction to feed the outgoing lines while C-81 and C-82 circuit breakers are removed for maintenance. Each of these two sections has 110/10 kV T-1 and T-2 step-down transformers. Their low-voltage winding also has two sections connected by a bus section breaker. It allows removing one of the transformers for maintenance by transferring the load to the other transformer.

Task: Removing the CB-110 1B circuit breaker at a 110 kV substation for maintenance.

Solution: To do the task, it is necessary to determine the sequence of operation. First, the equipment condition must be assessed: normally, CB-110 kV 1B is on and feeds the overhead line C-81 as shown in Figure 2.1.

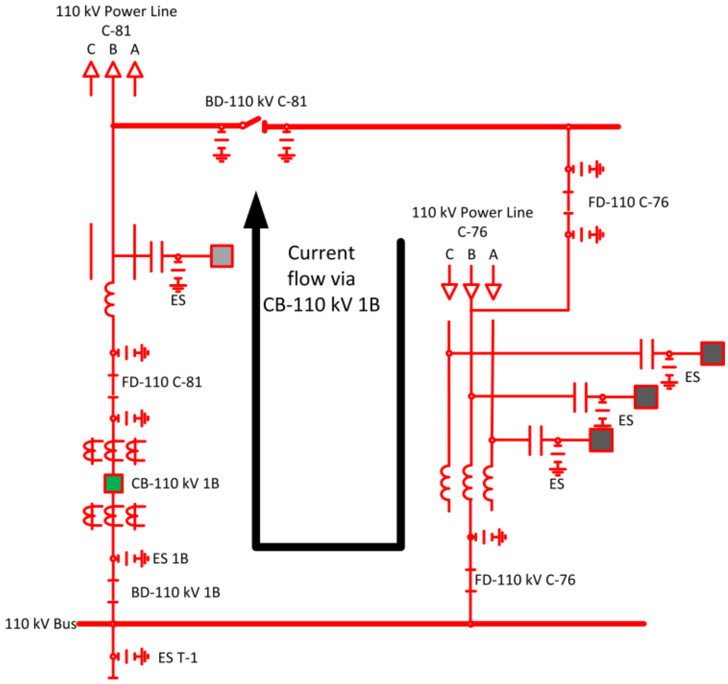


Figure 2.1 – Power supply diagram C-81 through CB-110 1B

To remove CB-110 kV 1B for maintenance, we must decide how to re-energize C-81. This can be done by activating the FD-110 kV C-81 disconnector, which allows unloading the CB-110 kV 1B. This power supply diagram is shown in Figure 2.2.

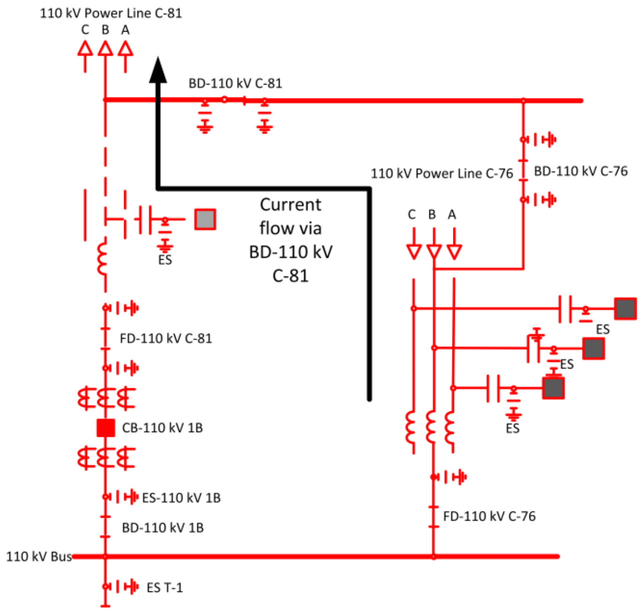


Figure 2.2 – Power supply diagram C-81 via D-110 kV C-81

For maintenance safety, CB-110 kV 1B is grounded on all sides, which can be used as a power supply, by installing the ES grounding switches on FD -110 kV and BD -110 kV 1B towards CB-110 kV 1B.

The correct sequence of operation to be developed by a student is:

a) perform automatic reclosing of CB-110 kV 1B;
b) check the disconnector columns DC-110 kV C-81;
c) turn FD -110 kV C-81 on;
d) turn CB-110 kV 1B off;
e) ensure that CB-110 kV 1B is off;
f) put the warning “DO NOT SWITCH ON, MEN ARE WORKING” on CB-110 kV 1B
g) isolate the control circuits CB-110 kV 1B;
h) de-energize the switch-on solenoids of CB-110 kV 1B;
i) check the column of FD -110 kV C-81;
j) shut FD -110 kV C-81 off;
k) check the column of BD -110 kV 1B;
l) turn BD -110 kV 1B off;
m) check voltage unavailability on BD -110 kV 1B towards FD -110 kV C-81;
n) activate the grounding switches ES -110 kV 1B towards CB-110kV 1B;
o) check voltage unavailability on FD -110 kV C-81 towards CB-110 kV 1B;
p) activate the ES on FD -110 kV C-81 towards CB-110 kV 1B;
q) check the columns of FD -110 kV C-81.

Figure 2.3 shows CB-110 kV 1B removed for maintenance with the ES activated on both sides in the direction of the circuit breaker.

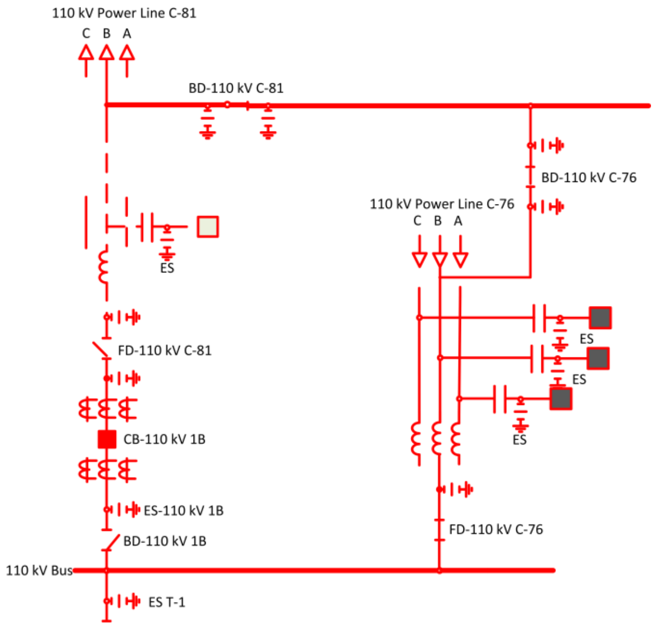


Figure 2.3 – CB-110 kV 1B removed for maintenance

2.2. Business game 2. Emergency Response Training Drills

Capacity growth and increased complexity of power systems make the work of a power system dispatcher or an operator more complicated. In most cases the first point and progression of emergency is inobservable. The operational personnel recognize a disturbance by the autoalarm system actuation, protective relay and automatics actuation, measurement deviations and blinking.

Meanwhile, account must be taken of a spurious tripping of unfaulted systems or undamaged device, failures of trip mechanisms, protective relay and automatic systems.

A technological disturbance always occurs suddenly and requires prompt actions, especially at the initial stage, when the staff is emotionally stressed and is not ready to respond properly. In this case, accurate and faultless operation can be ensured only if dispatchers have regular thorough trainings.

Emergency response drill.

Type of drill: emergency dispatcher training;

Drill subject: operational switching to remove the second bus section at 110 kV substation “*K*”; the crack of FD-110 kV C-18 insulator was detected. The defect must be eliminated;

Training method: conventional operation;

Training supervisor: a person responsible for the training (a teacher);

Trainees and an evaluator: students and a teacher correspondingly;

Training objective: to develop students' emergency response skills: to practice the proper sequence of operation in an emergency situation;
Providing input data and messages during training: the training leader announces the start; input data are provided by the evaluator during training;
Communication between training participants: orally, by phone;
Conventional time of emergency initiation: non-working day;
Equipment operation pattern before the emergency initiation: T-2 is on, T-1 is in standby, CB-110 kV substation *K* is on, CB-110 kV at the adjacent substation *Ch* is off. In total five substations are involved: *M* – operations with CB-110 kV C-18 and FD -110 kV; *K* – localization of disturbance, its removal for maintenance; *U* – protections transfer via transit lines 110 kV C-19, C-19 "a"; *B* – protections transfer via transit lines 110 kV C-20, C-19 "a"; *Ch* – opening of CB-110 kV and protection input on line 110 kV C-20;
Cause of disturbance, its development and consequences: during operational switching a crack on FD -110 kV C-18 insulator was detected.
Let us consider the correct sequence of students' operations:
a) during operational switching, a crack on FD -110 kV C-18 insulator was detected. According to the input task, switching must be interrupted to analyze the situation and specify the area to be localized following the fault detection. For safety reasons, it is necessary to de-energize the equipment and install grounding on the sides where voltage can be supplied from. Before de-energizing the faulty equipment, students must analyze the possibility of keeping the rest of the transit zone energized. The correct solution is to transfer the load of C-18 transit zone to C-21. The area to be localized must be marked at substation *K* scheme as shown in Figure 2.4.

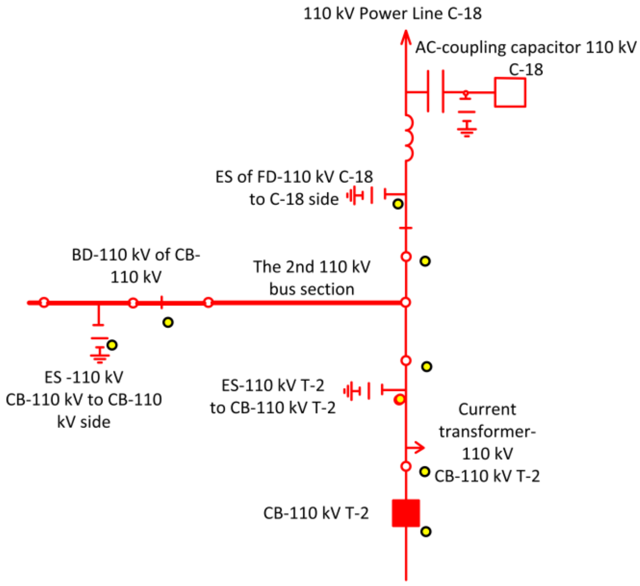


Figure 2.4 – The disturbance at substation K scheme

b) the first dispatcher-student shuts CB-110 kV C-18 substation *M* off and reports about it to the second dispatcher-student. Then, he must determine the proper sequence of operation after de-energizing C-18 by isolating the CB-110 kV C-18 circuit breakers at substation *M*. The transit zone C-18 – C-20 is de-energized, therefore, the disturbance area must be separated and the rest of the in-service equipment must be reenergized. It is not difficult to separate the disturbance area after C-18 de-energizing. A student must turn off BD-110 kV 2 B, BD-110 T-2, CB-10 kV T-2 at substation *K* (to prevent feedback in transformer circuit on T-2) and 100 V automatics of VT-110 kV 2 B voltage transformer. Once the disturbance area is separated, the rest of the scheme in service must be re-energized. Thus, a student must transfer the directional relay protection to C-20, C-19 "a", C-19 lines, and then turn on CB-110 kV at substation *Ch* and CB-10 kV at substation *K*, as shown in Figure 2.5.

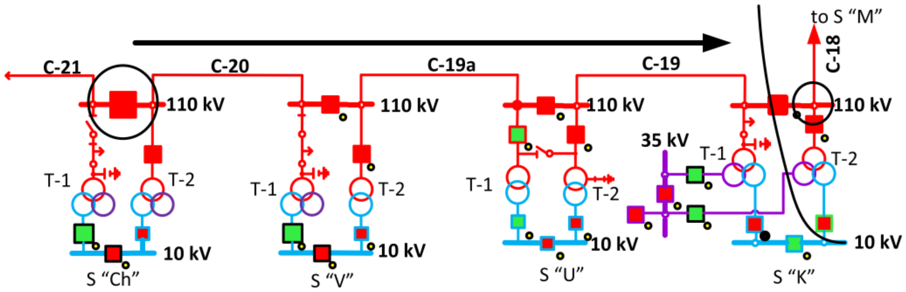


Figure 2.5 – Localization of the disturbance area at substation K, opening of CB-110 kV at substation Ch

c) a dispatcher-student activates the grounding switches on C-18 feeder disconnector of substation *M* towards the line. According to the input one side of DF -110 kV C-18 of substation *K* is already grounded by activating the grounding switches at substation *M*. Further on temporary groundings must be installed on both sides of the feeder disconnector, the workplace must be prepared for safe operation, and a work permit for disturbance removal must be signed. When remedial actions are over, a student must report about the disturbance removal and disconnect the grounding;

d) a dispatcher-student powers the grounding switches off on C-18 feeder disconnector at substation *M*. He must turn off FD-110 kV C-18 the rest of the in-service equipment. It is not difficult to separate the disturbance area after C-18 deenergizing. A student must turn off BD-110 kV 2 B, BD-110 T-2, CB-10 KV T-2 at substation *K* (to prevent feedback in transformer circuit on T-2) and 100 V automatics of VT-110 kV 2 B voltage transformer. Once the disturbance area is separated, the scheme in service must be re-energized. Thus, a student must switch over the directional relay protection on lines C-

20, C-19 “a”, C-19, then turn on CB-110 kV at substation *Ch* and CB-10 kV at substation *K*, as shown in Figure 2.5.

e) a dispatcher student activates the grounding switches on feeder disconnector FD C-18 of substation *M* towards the line direction. According to the input one side of DF -110 kV C-18 of substation *K* is already grounded by activating the grounding switches at substation *M*. Further on temporary groundings must be installed on both sides of the feeder disconnector, the workplace must be prepared for safe operation, and a work permit for disturbance removal must be signed. When remedial actions are over, a student must report about the disturbance removal and disconnect the grounding;

f) a dispatcher-student turns the grounding switches off on C-18 feeder disconnector at substation *M*. He needs to turn FD-110 kV C-18 at substation *K* off;

g) a dispatcher-student turns FD C-18 and CB-110 kV C-18 at substation *M* on. The disturbance has been removed. Switching operations can be performed.

Unit 3. Writing a scientific report and presenting it at a conference

Introduction

A thoughtful scientific report, written and presented in good English is the key to its subsequent successful publication and indexing in prestigious bibliographic databases to be internationally recognized. It should be borne in mind that the rhetoric of the text written in Russian differs significantly from the Anglo-Saxon rhetoric. According to the rules of English rhetoric, the author of the report should arrange it so that the listener does not have to puzzle over what the speaker had in mind. Russian academic writing involves a semi-structured text, which often does not have separate parts (in articles). The task of clarifying the order of ideas is performed through discourse (pragmatical) markers (introductory words), which can be omitted when translation, since English sentences are built more ergonomically. A good translation of the report into English is shorter than the Russian original by about 10%. In order to master the skills of stylistically correct selection of exact words from a synonymous chain; the ability to adequately and fully convey one's ideas by means of the English language; correctly and logically build sentences – you can use foreign and domestic textbooks teaching to write scientific reports in English. Some of them are in the reference list [9-12].

The keys for the success of a scientific research and a scientific paper are well-defined objectives, a sound and well-considered method, appropriate data collection and analysis, clear and concise conclusions and a skill of convincing writing.

Scientific and technical reports can be divided into four groups:

a) review;
b) theoretical research;
c) experimental research;
d) engineering development.

3.1. Writing a scientific report

3.1.1. Structure of a scientific report

The dominant structure for scientific reports is the so-called IMRAD structure (introduction, methods, results and discussions) which reflects the process of scientific discovery and helps the reader to browse through articles more quickly to find the relevant information. The extended structure includes the following:

- Title

- Introduction
- The main part
- Research methods and materials
- Results
- Discussion
- Conclusion
- Acknowledgments

Title

The title is the first impression you make on your audience. It discloses the basic information that the paper contains and helps readers decide whether to read the entire paper. The maximum length for a report title is 10–12 words. Very long titles like very short ones are difficult for listeners. The title of the report should be informative, concise, correspond to the scientific style of the text, and contain the main keywords characterizing the topic (subject) of the research and work content. When translating the title of a report into English, it is unacceptable to use transliteration from Russian into Latin, except for untranslatable proper names, device names and other objects; it is also not permissible to use jargon that is understandable only for Russian-speaking audience. It is undesirable to use abbreviations and formulas.

Introduction

The purpose of the introduction is to familiarize the listeners with the problem considered in the report, with its relevance, and possibly with the background. Writing the introductory part of a scientific report, you must answer yourself, at least two questions:

1) what kind of information would you expect to receive in this part of a scientific report?

2) what would maintain your interest to the subject and make you wish to listen the rest of speech?

The audience's interest in the report depends on the content of the introduction. The introduction should hold the attention of the audience. It reveals the general research topic, goals and objectives of the work, theoretical and practical significance. It includes a literature review to make clear to what extent the question has been addressed by others. However you should not summarize everything related to the topic.

The information should be organized according to the principle "from general to particular" and contain: description of the problem of which this study is a part; reasons why the research was undertaken; statement of the hypothesis and objectives you hope to achieve. You should explain the background and justify the need (feasibility) in your research in order to permit readers to evaluate the study's pertinence for their own work. The main arguments are usually the following: research has not yet been carried out by anyone, because this aspect of the problem was overlooked or ignored; there are contradictions or conflicts between the results of different researchers, hypotheses, conclusions; it is necessary to continue or expand the research, since there were not enough.

When pronouncing the introductory part of the report, it is useful to use some typical structural forms; some of them are given below.

a) The purpose of the studies, the results of which will be presented in the report, is to clarify the relationship between … and ..., which important when choosing ...

b) One aim of this report is to provide an analysis of… and to study ways in which… can be exploited to order to increase…

c) A continual need exists for reviewing and updating the state of affairs in such areas as…

d) We concur with B. and K. that theoretical work on…should be complemented with … data

e) Beginning in…, research and publications by W., and her colleagues modernized and popularized the idea of using … for the manufacture of … and…

f) The materials presented in the report were obtained in the course of the project on ..., which, in turn, is part of the state program...

g) The project provides for the identification of the quantitative dependence of ... on ... for its subsequent consideration in the design ...

h) Of great concern are cases of failure ... in modes ...

i) To eliminate the effect ... not only complex and time-consuming experimental studies were required, but also the development of a mathematical apparatus ... to extrapolate patterns in the field, inaccessible...

j) It also required consideration of fundamental mechanisms ..., which, according to modern concepts, can manifest themselves in the field of...

In abbreviated form, an Introduction section might look like this:

“The purpose of the experiment was to test conventional ideas about solubility in the laboratory [purpose] . . . According to Whitecoat and Labrat (1999), at higher temperatures the molecules of solvents move more quickly . . . We know from the class lecture that molecules moving at higher rates of speed collide with one another more often and thus break down more easily [background material/motivation] . . . Thus, it was hypothesized that as the temperature of a solvent increases, the rate at which a solute will dissolve in that solvent increases [hypothesis].”

Below are two examples of Introduction to the scientific report related to: a) renewable energy [13] and b) filled polymers used in the electric power industry [14].

Example 1

Energy is one of the essential elements of human life. This proves by increasing of the recorded global energy consumption. The record of peak energy in 2006 is 11,741 Mtoe. These energies are being used in every sector in industries and it been recorded more than half of the energy is converted to electrical energy. Due to increasing the demand for energy, the conventional resources make a huge impact on the environment and lead to the issue of climate change. Thus, much research has been done to enhance renewable energy such as wind and solar. The intermittent of the energy in the wind makes the researcher find a possible solution for maximizing the energy of the wind while it present. One of the solutions that have been introduced to overcome this problem is wind-diesel. Wind-diesel is a hybrid system that combination of wind turbines and diesel generators. This combination makes the system will have a maximum contribution to the intermittent of wind speed and give the continuous high-quality electric power into the system. In order to minimize the operating time for the diesel generator, high-penetration, no-storage wind-diesel has been introduced and it can save some of the fossil fuel resources. Thus, it also can lead to another pollution to the environment. The results of studies carried out by Tomilson, J. Quaicoe, R. Gosine and M. Hinchey (1998) have shown that it is better to avoid using energy storage devices as they tend to be more expensive and complex. It is very more economic to increase wind energy capacity than to add system storage to the system This improvement in the conversion of wind energy has led to the problem of frequency variation in the power system because the generator output fluctuates. Their article mentions that the control method of a high penetrating power and no accumulation wind diesel engine is difficult due to the change in wind speed. As you know, the power of a wind turbine is proportional to the cube of wind speed. Load changes make the control part of the system difficult. This is especially difficult to implement in an isolated electrical network, "island" type, which has little ability to control power.

Thus, this report will investigate the turbine characteristic and behavior of the frequency regulator in an isolated network.

Example 2

Electroconductive polymeric composite materials are actively used in electric power engineering, electro-physics, radio-electronic equipment, etc.; their use as self-restoring materials is also very promising. In this regard, the problem of developing instruments intended for selection of a predetermined property of the material for specific application field is urgent.

Instruments should recognize a multicomponent structure, since the character of the filler distribution determines the electrical conductivity of such materials over the matrix, interphase interaction, and amount of amorphous phase in the material. This suggests that the structural features thus formed can be seen in photomicrographs as a spectrum of gradations of grey color. The correctness of such approach was experimentally confirmed our previous research (Minakova N.N., Karpov S.A., Ushakov V.Ya. Russian Physics Journal. 2000. Vol. 43 (10), pp. 821–828; Minakova N. N., Ushakov V.Ya. Russian Physics Journal. 2016. 58 (11). pp. 1627–1634).

It was demonstrated that the electrical conductivity of filled polymers (FP) can be estimated from the entropy of the texture parameter. To determine it, a special procedure of image processing was developed including experimental selection of the cutoff threshold to transform the image into black-and-white form and of the size of zone for which the value of the texture parameter was calculated. Such a fine adjustment of the parameters complicated the image processing.

The assumption has been made that the use of a complex of the parameters of the texture pattern instead of one parameter (entropy of the texture parameter) will allow one to consider a wide complex of changes of gradations of grey color in the image and to adjust the estimation "structure – properties" to a concrete electro physical parameter.

The following problems were solved as:

a) Selection of the method of FP image transformation into a binary image with automated determination of the cutoff threshold;

b) Choice of a complex of texture parameters that admits estimation of the FP "structure – properties" interrelation;

c) Experimental check of suitability of the chosen parameters for estimation of the electrical conductivity value.

The choice was made in favor of the technology based on application of the well-known models of color space analysis. The YUV model was used to select the brightness signal. The binarization threshold was calculated automatically for each image using Otsu's method from the image histogram (sampled values from 0 to 255). A program of image processing was developed.

The texture parameters are conventionally structured as follows:

a) Parameters based on measuring spatial frequencies;

b) Parameters based on statistical characteristics of the intensity levels of decomposition elements;

c) Parameters based on description of structural elements.

Based on an analysis of the special features of the FP macrostructure, the parameters based on statistical characteristics of the intensity levels of decomposition elements were chosen in the present work. A complex of the texture parameters of the macrostructure image was analyzed instead of a single texture parameter suggested by Minakova N.N., Karpov S.A., Ushakov V.Ya. (Russian Physics Journal. 2000. Vol. 43 (10), pp. 821–828). As textural parameters, we have chosen the second-order angular momentum, contrast, correlation, variance, first moment of inverse difference, total average, total variance, total entropy, entropy, and differential variance. Choosing these parameters, we hoped that they would allow us to estimate differences and brightness gradients of the macrostructure image to detect minor changes in the gradation of grey color.

Main Part

This part of the report is the most informative. Methods and results of solving the considered scientific problem, substantiation of the assumptions and conclusions made are presented in detail.

Research Methods and Materials

In this part, it is advisable to first give a general scheme of experiments / research, then talk about them in such detail that any competent specialist can reproduce them, as far as the time limit allows. When using standard methods and procedures, it is best to cite relevant sources, remembering to describe modifications to the standard methods, if any. If you use an original method that you have not previously described, then you must give all the necessary details.

The section Theoretical Basis should include mathematical calculations with such a degree of detail that they can be easily reproduced and the correctness of the results obtained can be checked. Provide all the necessary data, formulas, equations, name what transformations were performed on them.

The statistical procedures should be presented very briefly, as in most cases the methods of statistical analysis and their modifications are well known. Standard statistical procedures should only be named; reference to the source is only needed if you use unusual or modified methods.

Standard type forms are also widely used in explaining the research methods of solving a problem**.** As a rule, such typical forms are used in conjunction with transitional words and phrases that connect the performance into a logical whole.

A relevant example for theoretical research is given below:

a) Modernization of the equation ..., previously used only to describe ..., will allow you to obtain the desired change in the parameter .... in the form of an expression ... where ...

Results

Research results should be presented in a processed version: in the form of a well-formulated text, tables, graphs, diagrams, equations, photographs, drawings. This section provides facts only. Their interpretation, comparison with the data of other researchers should be included in the Discussion section.

There are three ways to present the results:

a) text (verbal presentation);
b) tables (semi-verbal presentation);
c) pictures: diagrams, graphs, images (visual representation).

All ways of presenting results should complement, not duplicate each other. Every graph, every table shown to listeners should be commented. In this part of the report, transition words and expressions are often used.

Illustration: as shown by, e.g., especially, for example, for instance, in particular, namely, particularly, specifically, such as, that is, to illustrate.

Addition: again, and, also, besides, equally important, first (second, etc.), further, furthermore, in addition, in the first place, moreover, next.

Comparison: also, in the same manner, likewise, similarly.

Contrast: although, and yet, at the same time, but, despite, even though, except, however, in contrast, in spite of, nevertheless, on the contrary, on the other hand, regardless, still, though, unlike, whereas, yet.

Logical relation: accordingly, as a result, because, consequently, for this reason, hence, if, otherwise, since, so, then, therefore, thus.

Temporal relation: after, afterward, as, as long as, as soon as, at last, before, during, earlier, finally, formerly, immediately, later, meanwhile, next, since, shortly, subsequently, then, thereafter, until, when, while.

Spatial relation: adjacent to, above, below, beyond, close, elsewhere, here, nearby, opposite, to the right, left, north, east, south, west, etc.

To summarize or conclude: in conclusion, in summary, on the whole, that is, therefore, to conclude, to sum up.

As a rule, such typical forms are used in conjunction with transitional connecting words and phrases that connect the performance into a logical whole. Relevant examples are given below.

a) Figures ... illustrate the calculated (dashed) and experimental (solid) dependencies… on ... when changing ... to the extent available to instruments for measurement ...

b) However, other components of the … also play an important part in the achievement of … since they influence the interaction between … and …

c) The diagram facilitates the determination of the relationship for … conditions

d) From the analysis of the calculated and experimental data it follows that the solution of the problem is rather to be sought in the region of more predictable design and better interaction between ... and …

Discussion

This section contains the interpretation of the results obtained and their comparison with the results obtained by other authors. In the Discussion, it is necessary:

a) to remind about the purpose and hypothesis of the research;
b) remind about the main results obtained and summarize them;
c) compare your own results with the data of other researchers;
d) provide possible explanations for their similarities and differences (and sometimes contradictions);
e) note how the results correspond to the hypothesis of the study;
f) indicate the boundaries of generalization of the results obtained and their nature;
g) formulate recommendations for the application of the results in practice or in theoretical research.

Conclusion

The purpose of the conclusion is to briefly summarize the main results obtained by the author / authors and general conclusions that can be drawn on their basis. This section should be carefully edited to avoid repeating the wording in the previous sections. It is advisable to compare the results obtained with those that were planned to be obtained, as well as to show their novelty and practical significance, to name the limitations encountered in the course of the work. In the concluding remarks an assessment of the prospects for scientific and technical topics, the development of which was considered in the report, is quite appropriate.

For conclusion, the following structural forms are relevant:

a) It has been shown that …
b) Based on …, it is concluded that …
c) Thus we are fully justified in observing that …
d) … and … are among the most meaningful results of study
e) The totality of the materials presented in the report and those that were not included in the report due to its limited volume allow us to draw the following general conclusion ...

Below are the examples of Conclusions to the reports that were used to illustrate the Introduction.

Example 1

The presented Asynchronous Generator based Wind Turbine in Isolated Network has been modeled and simulated by using the MATLAB/Simulink environment. The important models of all isolated network components have been introduced. Moreover, the discrete frequency control and excitation system that has been designed to make the output power of the independent grid more reliable are also presented in this paper. The first section covers the operation of the wind turbine Asynchronous Generator with various load conditions. Moreover, the voltages, currents, power levels, asynchronous machine speed, and system frequency have clearly been observed.

Then the frequency of the isolated network has been discussed in detail to comprehend the impact of various load conditions on them. In addition, the frequency deviation due to connecting the additional load of 25 kW is seen. Also, the reasons for this frequency disturbance are recorded clearly. Additionally, the frequency signal is observed clearly how it became stable at the ends and the reasons for this frequency behavior are given in this report. Furthermore, the third part of this paper discussed briefly voltage profile during the initial state as well as the impact of added load on the voltage profile in the system. It has been noted that voltage is dipped at 0.2 s after integrating additional load to the system. To sum up, these reports explain clearly the operation principles of asynchronous generators. It also gives a clear picture of what happened to the power system and its frequency if the loads absorb power higher than the generated value.

Example 2

a) The approach to the analysis of the texture pattern of FP macrostructure images has been suggested based on the widespread UYV and Otsi models of analysis of color space.

b) The monotonic change of the parameters of the texture pattern of the image with increasing filler concentration was established. It was found that the dynamics of variation of the parameters was different.

c) It was established that from the investigated parameters of texture pattern, a maximal change accompanying variations of the electro conducting component was characteristic for the parameter “contrast”.

d) It was shown that for a concrete electro physical characteristic, a parameter of the texture pattern could be chosen that had analogous ranges of variations when two materials were compared.

e) The characteristics of the texture pattern close in values to the electrophysical characteristics considered in the work were revealed.

f) It was established that the parameters of the texture pattern of the macrostructure image could be used for prognostic estimation of the electrical conductivity of the filled polymers.

g) The possibility of individual selection of the texture parameters to obtain desirable electro physical FP characteristics was demonstrated.

Acknowledgments

In this section, it is customary to express gratitude to colleagues who helped with research or critically commented on your report. If you used non-standard equipment and materials in your work, then you can also indicate on what and whose special equipment the experiments were carried out, as well as the sources of all other special materials and research objects. It is also necessary to thank the organizations and foundations for the financial support of the research, i.e. to name under what grants, contracts, scholarships it was possible to conduct research. (e.g., *the Russian Foundation supported this work for Basic Research, project No.…*).

3.2. Presenting a scientific report at conferences

Presenting at a conference is a core part of scientific communication for any researcher or academic. The perception of your report depends not only on the novelty and quality of the results of your research or analytical review, which are the subject of your presentation, but, largely, on its quality. The key to an effective conference presentation lies in being well-prepared. Here are a few tips that will make the process smoother for you.

3.2.1. Eleven key tips for a presenter

Know exactly how to start

Plan the first minute of your presentation. Try to memorize your opening words. Try to make at least one powerful statement in the first two minutes. This will help you feel confident, in control (of yourself and the audience).

Talk to your audience

The best presentations sound more like conversations. At the beginning of your talk, welcome the audience and tell them how grateful you are they are all here to listen to you. Respond to audience reactions. Making eye contact can help you connect to the audience and prevent you from reading the slides.

Be concise

Keep your sentences short and simple. Use deliberate pauses to punctuate your speech. Start with context describing the pioneering works of others in the field, then go on to show your unique contribution to the field. In the logical order provide highlights of what you did tied to the audience’s expertise.

Speak naturally

Don't be afraid to hesitate when you speak, but make sure you pause in the right places. Remember, you are not an actor trying to remember lines. A certain amount of hesitation is actually quite natural. A moment of silence as you gather your thoughts can make the audience pay attention. Don’t feel you have to talk continuously and avoid filler phrases, like “you know”.

Know your audience

Speak for your audience, not for yourself. Take every opportunity to show how much in common there are between the scientific problems that you and other conference participants are solving. Get an insight to exactly who is attending the conference and what their speciality topics are from the programme. This can give you a good idea of how much background you need to give so that your key presentation points will make sense.

Take your time

Whenever you make an important point, pause and let the full significance of what you have said sink in before you move on.

Let your visuals speak for themselves

Good visuals are just that - visual. They help to convey your scientific message better and are more memorable than text. Do not put boring tables of figures and long lines of text on the overhead and read them out. Stick to the main points. Experiment with three-dimensional charts, cartoons, and interesting typefaces – anything to catch your audience's attention.

Never compete with your visuals

When showing a visual, keep quiet and give people time to take it in. Then make brief comments only. Point to the relevant parts of the visual as you speak. If you want to say more, switch off your projector to do so.

Develop your own style

Learn from other public speakers, but do not try to copy them. Be comfortable with your own abilities. Do not do anything that feels unnatural for you, just because it works for someone else.

Welcome questions from your audience

When members of your audience ask you a question, it is usually because they have a genuine interest in what you are saying and want to know more. Treat questions as an opportunity to get your message across better. Many presenters fear the question that comes from the audience after their talk more than the presentation itself. Prepare yourself: What potential questions could the audience ask? Presentation questions are a good thing. They give you a chance to elaborate on something that wasn't clear or address the topic that everyone wants to know but you forgot to include.

Finish strongly

When you are ready to finish your presentation, slow down, and lower your voice. Look at the audience and deliver your final words slowly and clearly. Pause, let your words hang in the air a moment longer, smile, say:" Thank you!" and then sit down.

3.2.2. Requirements for the design of visuals materials

a) Make your slides attractive and neat. Use a unified color scheme, e.g., corporate colors of your university. The universal rule is to use not more than three different hues. Use a color wheel to find color harmonies, make the images hard to look and note that the slides must be stylish;

b) Create a unified design for all slides and take note that all makeup elements are in their places;

c) Add quality images. They must be supportive, not distracting from the message. Use simple one-color icons;

d) Flow charts and diagrams must be distinguishable, flat and clear;

e) Add something special to the presentation, e.g., use video in the introduction;

f) Review the solution and make sure that all figures are correct and there are no misprints. If necessary, improve it.

g) Mind that creativity must be beneficial and powerful.

References

1. Gustafsson J. Single case studies vs. multiply case studies: a comparative study (Thesis). Halmstad, Sweden: Halmstad University, 2017
2. Yin RK. Case study research: design and methods. 2nd edition. Thousand Oaks: Sage, 2003/
3. New Zealand case studies in information systems/ edited by Val Hooper, Auckland, N. Z.: Pearson Education, New Zealand, 2007, 50 p.
4. John Gerring, What is a Case Study and What is it Good for? American Political Science. Review. Vol. 98, No2, May 2004, 341-354 pp.
5. Dawson R. Hancock and Bob Algozzine, Doing Case Study Research. A Practical Guide for Beginning Researchers. Published by Teachers College Press, 1234 Amsterdam Avenue, New York, NY 10027, 121 p.
6. Gary J. Summers, Today's business simulation industry. Simulation & Gaming. Vol. 35, No. 2, June 2004, 208-241 pp.
7. Chang, M. T. J., The use of business gaming in Hong Kong academic institutions. Simulation & Gaming, Vol. 34, No. 2, March 2003, 358-366 pp.
8. Faria, A. J., Wellington,W., A survey of simulation game users, former-users and never-users. *Simulation & Gaming*, Vol. 35, No. 2, June 2004, 178-207 pp.
9. Glasman-Deal H. Science Research Writing for Non-Native Speakers of English. Imperial College London, UK, 2010.
10. Alenkina T. Academic Writing in the Sciences: Theory and Practice. M.: МФТИ, 2015. 276 c.
11. Galko F.D. Better Writing Right Now! Using Words to Your Advantage. New York: Learning Express, LLC, 2002.
12. McCormack J. Extended Writing and Research Skills / J. McCormack, J. Slaght. Reading: Garnet Education, 2012.
13. Lukutin B., Kadhim K.H., Jbarah, Ali N., Karrar O. Modelling and Simulation of Behavior for AGBWT in Isolated Network using Simulink/MATLAB March-April 2020, ISSN: 0193-4120 Page No. 15245 – 15249 Published by: The Mattingley Publishing Co., Inc. 15246.
14. Minakova, N. N., Ushakov V. Ya. To Refinement of the Estimation of the Electrical Conductivity of Filled Polymers from Texture Pattern of the Macrostructure Image, AIP Conference Proceedings. – 2019. – Vol. 2167: Advanced Materials with Hierarchical Structure for New Technologies and Reliable Structures 2019 (AMHS'19).

Учебное издание

БАЦЕВА Наталья Ленмировна
ЧЕСНОКОВА Ирина Анатольевна
УШАКОВ Василий Яковлевич
НИКИТИН Дмитрий Сергеевич
ХОХЛОВА Татьяна Евгеньевна

Цифровая энергетика

Практикум на английском языке для самостоятельной работы студентов

Учебное пособие

Издано в авторской редакции

Корректура *И.О. Фамилия*
Компьютерная верстка *И.О. Фамилия*
Дизайн обложки *И.О. Фамилия*

Подписано к печати 00.00.2020. Формат 60.84/16. Бумага «Снегурочка».
Печать CANON. Усл. печ. л. 0,00. Уч.-изд. л. 0,00
Заказ 000-18. Тираж 100 экз.

Издательство
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Digital Power Industry

Practical self-study course for students in English

N.L. Batseva, I.A. Chesnokova
V.Ya. Ushakov, D.S. Nikitin T.Y. Khohlova