ASPECTS OF DEVELOPMENT OF POWER INDUSTRY IN AZERBAIJAN UNDER MARKET ECONOMY CONDITIONS

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Number of problems relating to the development of the power industry of Azerbaijan: elaboration of optimal and long-term programme for the development of generating capacities, conduct of structural reorganization in compliance with the instructions of European Union (EU), work out and introduce multi-tariff payment system for the electric power, upgrade and modernization of power equipment, usage of SAIDI and SAIFI values in evaluating the reliability of consumers' power supply, application of methods of "alive works", design of modern dispatching systems for controlling all the structures of the power industry are reviewed.

***Key words*:** Generating capacities, multi-tariff system, reliability of consumers, dispatching systems, structure, of power industry, infrastructure of the field.

Some aspects about the development of the power industry of Azerbaijan are provided in the author's article [1] published in 2009. This article continues and completes the problem relating to the development of the country's power industry.

In working out the concept of the development of the power industry, it is extremely useful to study the experience of the countries in which the power companies were state, national companies with centralized management (like conditions in our country).

One of such countries is France and its national company Electricite De France (EDF).

The example of EDF in terms of working out optimal long-term concept of the development of the generating capacities is quite indicative [1].

Azerbaijan became the member of the European Council and is getting ready to became the member of EU. For this, the country should satisfy EU's requirements in various fields including the power sector.

Let's review laws adopted for establishing an integral European power market in chronological order [2]:

- directive on electricity dated June 26 2003 substituting the directive dated 1999;
- order for regulating power exchange between the countries dated June 26 2003.

These directives and laws allow to establish equal, competitive conditions for the producers, network and system operators as well as power consumers at the EU power market in accordance with the principals of the market economy.

Based on these directives, each country being the member of EU, adopted its own laws and runs structural reorganization in the power industry, and also founds an appropriate body regulating mutual relations of these structures having the role of a "judge" among them. Such bodies are called "regulators". Similar "regulator" was founded at the EU level.

Original bodies of the power systems being the member of EU were different and varied from one another. Thus, in France, as mentioned above, this was the unified national company, and in Germany it consisted of number of private companies. The unified national company generated, shipped, distributed and sold power itself. There was the monopoly on power generation and sales in these countries.

As an example let's review the power system of France which before conducting the structural reorganization according to the requirements of EU was closer to the conditions of Azerbaijan.

France adopted the following laws based on the directives of EU:

- law on electricity dated February 10th 2000 based on the directive of 1996;
- laws dated August 9th 2004, June 13th 2005 and December 7th 2006 based on the directives of 2003.

In accordance with these laws, under the pressure of EU, regardless of the objections and strikes from the EDF side and its employees, the structural reorganization was run.

Thus, on 22.02.2005, under the Decree #2005-172 of the Prime Minister of France, specific body – transport power network RTE (Reseaux Transport Electric) was isolated from the EDF group, the above body was isolated from EDF and was under the state's subordination – this is the entire high voltage network of the country through which intergovernmental relations with the neighboring countries and their power networks were conducted, which is why it has strategic importance for the safety of France too. The same happened with the distribution power network of EDF (Electric Reseaux Distribution France) operating under 20 kW voltage.

Power generation is totally liberalized, any company and legal entity have the right to generate and sell power. Due to the fact that other French companies can also generate power together with EDF, there arose the necessity of establishing fair and equal options to connect to the transport and distribution power networks (public networks). Given this, RTE and ERDF were disengaged from the subordination of EDF general management and became independent entities. Candidacies on the director's position of such entities are approved by French government. Observation Council of the activities of RTE and ERDF headed by Mr. Andre MERLIN, CIGRE President was founded in 2009.

Market economy envisages availability of competing companies generating and selling power. All these companies should have equal rights to use the above two entities RTE and ERDF for power transportation and distribution.

As the practice of the performed structural reorganization of the state and national power companies, like in our country, in compliance with the requirements of EU, shows there should be at least three entities, transport company like RTE, distribution company like ERDF and the producing - generating companies which may be in large quantities.

One of the important aspects for the development of the power sector in Azerbaijan is to work out and introduce the multi-tariff payment system for power. Such a payment system has been applied during decades in many developed and not so much developed countries. It should be noted, that the double-tariff system was applied in Russia since 2000 and since early 2008 they switched to the five-tariff system [1].

We assume, that the application of the multi-tariff system in our country will allow to reduce power consumption at rush-hours by more than 20-30 million kW/hour. The country's population makes over 8 million and almost all the families have household devices programmed on night operation mode and also electric devices for heating water in the villages. In regulating the daily load demand, it will be possible to reduce the consumed power at evening and daytime hours when the load achieves the maximum level.

Along with this, it is provided in article 2.2.8. of Resolution #18 dated February 2nd 2005 of the Cabinet of Ministers of Azerbaijan – " Regulations on Power Usage" - that it is compulsory for the consumers to satisfy the requirements for regulating the daily loading demand. It is obvious that without relevant metering units and multi-tariff system it is impossible to fulfill the above article on "Rules". We mean issuing "technical conditions" considering the connection of a new load beyond evening and daytime period when there is the maximum load of the power system.

For solving the above problems it is reasonable to work out and introduce the multi-tariff system based on the experience of other countries which will be applicable to the conditions of our country.

Committee on regulating power (CRP) is called "regulator" too. Such "regulators" are founded in all EU countries [2].

One of the most important problems of their activities is raising the quality and reliability of the power supply [3].

31 EU countries adopted new European standard EN 50160-2007 on the power quality [4]. In accordance with this standard not only traditional deviation and oscillation of voltage and frequency, harmonic group, unsinusoidality and asymmetry of voltage, issues of overvoltage and flickers, but the quality of uninterruptible power supply are meant under the power quality.

Article 3.18 "power supply cut-off" is included in European Standard EN 50160-2007, which is about the quality of not only the supplied power, but about the reliability of the power supply. Under article 3.18 the power cut-off may be classified as:

- scheduled, when the network consumers are informed about performing planned works at the distribution network in advance, or
- accidental, when they are provoked by unavoidable or self-correcting failures, in most cases associated with external events, accidents or external reasons. Accidental cut-off can be classified as [4]:
    - long-term cut-off (exceeding 3 minutes);
    - short-term cut-off (up to 3 minutes).

Note 1. Consequences of the scheduled cut-off may be minimized by the network consumers in case of taking measures in advance.
Note 2. Accidental cut-off are unforeseen and basically accidental.

French distribution network publishes the report with statistic data about power cuts and accidents every year [5]. All the failures are classified by types in detail, more characteristic ones are identified, and various network regions are compared to one another. Damages in cables and overhead circuits take significant place in the statistics. It seems reasonable to borrow from French statistics relative values of the damage of cables and overhead networks, i.e. relative values on the damage per 100 km are applied in it. Such relative values of the damage allow to more fairly compare the network condition and solve the problems relating to the investments. In

absolute number of damages it does not seem possible to accurately compare the condition of cable lines and overhead circuits in various networks of the distribution networks.

One of the basic indicatives of the power network operation is total reduction of the power cut-off time, particularly at high, medium and low voltages.

In ERDF the power cut-off time is characterizes by criteria C (at medium voltage CH) and H (at a low voltage HH) representing the cut-off time to which the consumers of CH and HH were subject.

These criteria are calculated with the expression:

$$C = \frac{\sum(PS \times t)}{P_S},$$

where PS – capacity of the consumers cut-off CH; t – cut-off time, min.; P_s – total declared capacity of the consumers CH;

$$H = \frac{\sum(n \times t)}{N},$$

where n – amount of the cut off consumers HH; t – cut-off time, min.; N – total amount of the consumers HH.

Criterion C is the sum consisting of the following values: accidents and repair works at the side of medium voltage as well as the cut-off caused by the power generation and transportation problems. Criterion H together with the above values, also includes the accidents and repair works at the side of low voltage.

According to the above mentioned standard, such two main characteristics for the quality evaluation of uninterruptible power supply as the values of SAIDI and SAIFI are introduced.

The first shows the time of the consumers cut-off within a year and the second – average amount of the consumers cut-off within a year.

SAIDI, min, generally is calculated according to the expression:

$$SAIDI = \sum N \times T / N_в ,$$

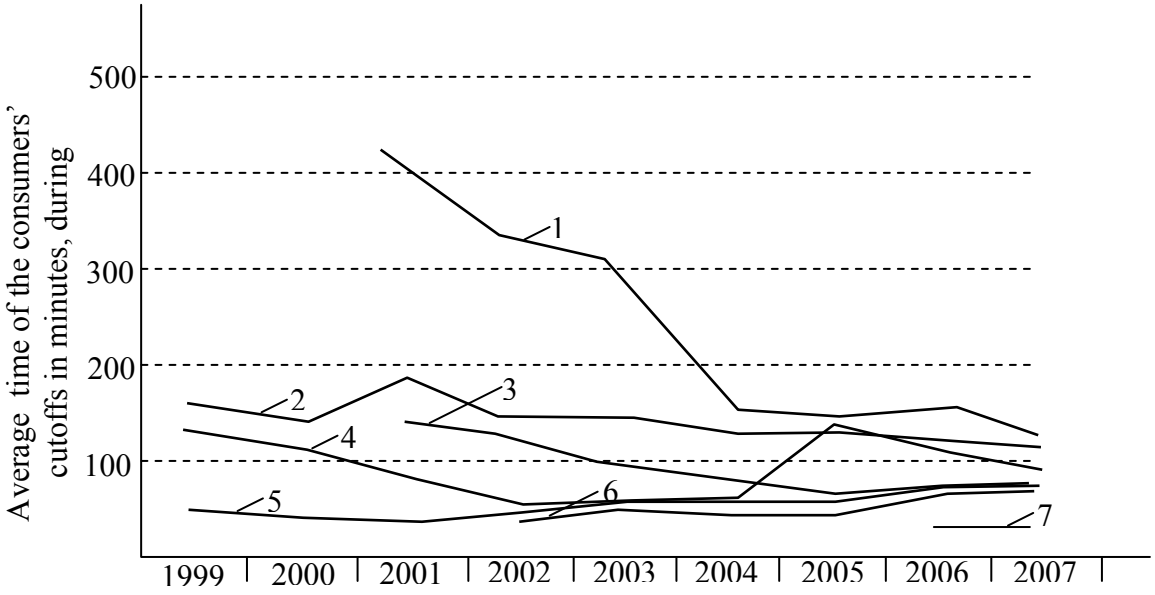
Where N – amount of the consumers cut off and relative time T, min; $N_в$ – total amount of the consumers .

SAIFI values are very simply calculated based on the results of the statistics about the cut-offs. Besides, as mentioned above, the cut-off should be split into the long-term and short-term ones.

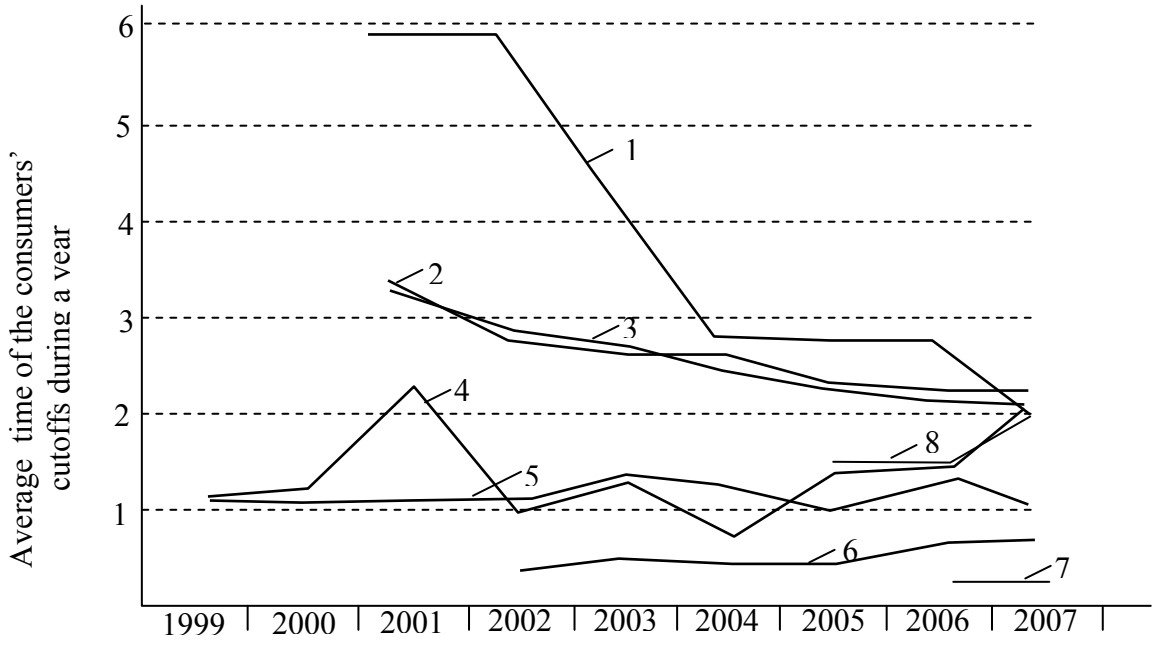
It should also be noted, that year by year the cut-off time gradually decreases. According to the statistics of 1973, the SAIDI type value by the French distribution network made some 10 hours and in 2000 it made 50÷60 min. French specialists believe that such a progress is basically achieved on the account of wide application of alive works and also by dispatching and remote control of the network.

Contemporary dispatching centers of the developed countries allow to control both separate elements and the entire network remotely enabling to restore the power supply of the most part of the cutoff network within the minimum time contributing to significant reduction of the SAIDI values.

As an example there are SAIDI and SAIFI of 11 European countries within the years 1999-2007 provided on figure 1 [3].



a)



b)

Figure 1.

a) SAIDI; b) SAIFI: 1 – Portugal; 2 – Spain; 3 – Italy; 4 – Island; 5 – France; 6 – Austria BH, CH; 7 – Germany; 8 - Estonia

Each distribution network of EU countries undertakes particular obligations to the consumers during a year. For example, during a year the SAIDI value will not exceed the defined time (for example 50 min), SAIFI value will not exceed any amount of the cutoffs during a year either (for instance, 7 cutoffs the duration of which exceeds 3 min, and 9 short-term cutoffs the duration of which makes from 1 to 3 min).

In accordance with the requirements of EU, our distribution networks should get prepared for similar obligations to the consumers.

Depending on how these responsibilities are fulfilled – fully fulfilled, overfulfilled or unfulfilled – there is encouragement and penalty system. For instance, in case the French distribution network ERDF does not fulfill its obligations according to the SAIDI value during a year, than it will be fired in the amount 4 million EUR and for overfulfilling its obligations it will get bonus in the amount of 4 million EUR.

There are other encouragement and penalty methods taken in some EU countries, for instance, in Portugal there is particular time defined within which the network supply can be cut off. If such time is decreased by 12% within a year, than the power distribution company gets bonus in the amount of 5 million EUR, and if this time is increased by 12%, than the company is fire in the amount of 5 million EUR.

Decision about the bonuses and penalties in France is agreed with CRP, and in Portugal it is also agreed with the entity like CRP.

As mentioned above, the application of the method of alive works allows to decrease the amount and time of the cut-offs in power networks [5].

In many developed countries the alive works have been performed within many decades. In France they were applied since the middle of 60ies of the last century. Since 1964 such works were performed at low, medium and high voltages [6].

Since the works at our power networks are not performed alive and there is not enough information available about this, let’s discuss this issue in a more detailed way.

There are three methods of alive works according to the location of an operator against the components being under the tension and the means used for protecting from risks relating to electrical shock.

“Distance” method: the operator is located on “grounding” potential. The operator maintains minimal distance against the components under the tension working with the instruments (devices) fixed at the end of the isolated bar.

“Potential” method: the operator settles on the elevator with the sleeves isolated from the grounding potential, contacts with the potential conductor on which he works maintaining minimum distance with the other potentials.

“Contact” method: the operator settles on the elevator with the isolated sleeves, wears long isolated gloves and directly contacts with his working potential maintaining minimum distance with the other potentials.

Below are the alive works more frequently performed at the distribution networks:

- breaking and closing simple circuits;
- breaking and closing circuits with large capacity transit;
- repairing conductor under the tension;
- repairing conductor at the finite part of the support;
- replacement of the suspended insulator;
- remote replacement of the insulator;
- replacement of the supporting insulator;
- replacement of dual supporting insulator;
- establishment of line breaking points;
- replacement of fittings;
- current repair of the breaker on the support;
- replacement of the support;
- replacement of the support with breaker.

The alive works are performed under low, medium and high voltages. The methods to satisfy the demands of the network operators are worked up and developed. Analysis of the risks while working alive for all types of operations and for all units are designed.

Current technology is at service of the team of "alive works" (AW):

- 300 kW high-voltage test chamber;
- up to 800 kW mechanic test bench;
- over thousand of various specific tools and devices;
- various machines and mechanisms including helicopters;
- training centre for preparing staff.

SERECT company conducting works for RTE and ERDF and for thousands of foreign network and system operators is involved in the alive works in France. SERECT is "service for research, realization and experimentation of the committee for alive works".

The alive works are continuously expanding and improving. The technology allowing to work not only alive but under rain too was worked out recently.

There is a standard of International Electrotechnical Committee for the performance of the alive works [7].

For the purposes of raising the reliability of the consumers' power supply it is important to study foreign experience of the alive works and introduce it into the practice of the operation and repair of our transport and distribution power networks and prepare legal, methodical and instrumental base for the performance of the alive works.

The key problem is an upgrade of power equipment. There is large amount of old both sub-station and station equipment in the power industry of Azerbaijan. Together with their replacement it is necessary to establish certification system of the purchased and installed equipment in order to avoid getting of the power equipment not satisfying the international norms and standards at the power market. Together with this, the upgrade of the power equipment should have system nature at some point meaning that the reinstalled equipment should be tied up to other systems, particularly to the dispatcher control system so that it satisfies the requirements of the remote control and information technologies. Thus, it is preferable to

have the design for the dispatching monitoring and control system and then to proceed with the system modernization of the power equipment.

Improvement of voltage quality especially in winter time is significant as well. At some network areas with low voltage quality, the consumers observe the following problems:

- necessity to install various types of stabilizers (for household electric devices);
- in switching on water pumps in multi-storey buildings, when the voltage exceeds admittable limits, it is impossible to switch on the pumps when needed and the consumers have to wait for the establishment of the admittable voltage range;
- installation of powerful stabilizers for the power supply of the plant partially or fully (reliability of the operation of the powerful stabilizers of over 60 kW available at our market should be improved).

It is obvious that switching of the stabilizers and other equipment in line results in the irrational power usage, occurrence of excess nonproductive level of translating equipment and rise in nonproductive losses in the network not to mention expenses incurred for the purchase of the equipment for stabilizing voltage.

One of the ways to solve this problem is usage of transformers to regulate voltage under the load just the way this is done in foreign developed countries. From one hand we lack such transformers and from the other hand, due to unsafety and imperfection of soviet regulators, the operators prefer not to use them. For improving the voltage quality, it is necessary to use transformers with modern, safe regulators of voltage under the load.

The issues of the power system control are principally important. The most effective is centralized control of the power system. It allows to handle system accidents more quickly and effectively. The main objective is not to allow the development of the accidents that may lead to the failure and, of course, to the disconnection of the entire power system, especially, as mentioned above, it relates to Azerbaijanian ГРЭС, the capacity of which makes approximately half of the entire country's established capacity and hence, its loss may lead to quite dangerous and even catastrophic consequences due to the imbalance of generated and consumed capacities, when even frequency unloading may not help.

Even in cases when the power system consists of many private companies, for instance like in USA, in the emergency conditions, when there is the danged of the collapse of the entire system, it is necessary to consider it as an integral unit with the centralized control. The experience of the control and operation of the power systems shows that there are less accidents with the collapse of the entire systems or of its most part observed in cases with the centralized control. Large blackouts in the New York state and its neighboring states in 1965, 1977 and 2002 when tens of millions of residents were without power for a long time can be brought as an example.

In case of the centralized control, usage of anti-accident automated mechanisms and means to avoid the blackouts in significant lack of the generated capacities is much simpler.

In case of integrating Azerbaijanian power system into the world system, international norms and standards should be followed. It is necessary to actively participate in the international organizations (MEC, CIGRE, etc.), to become their member and have our own national committees in such organizations. In main power entities there should be structural subdivisions handling the problems of the international norms and standards as well as with the international power organizations.

Unfortunately, participation of our country in such international organizations is quite poor. For instance, just "Bakelektrikshebeke" was collective member of CIGRE in 2008 and its representative participated in the 42nd work session of CIGRE in Paris in August 2008. Russian delegation was presented at this session by 100 members and two students of energy faculty of Petersburg and Ural Polytechnical Institutes [8] who won All-Russian contest and were awarded sponsor's financial support.

Certainly, we do not appeal to directly copy quite a successful example of the development of French power industry or the power industry of any other country.

Of course, each country has its way of development, its initial conditions and preconditions and potential. The aim is to make proper choice, work out an optimal scientifically justified long term concept for the development of our country's power industry based on studying and generalizing the other countries' experience.

It is impossible to throw light on all the aspects of the conditions and development of the power industry of Azerbaijan in one article. It was just our attempt to highlight the most important problems of the power industry and draw the attention of scientists and specialists and appropriate ministries and departments to these important problems.

It is necessary to run large complex of works including the works relating to the concept and strategy of the development of the power industry. There are the scientists and specialists in the power sector of the country who could have participated in the discussions, elaboration and preparation of the decisions of actual problems. Invitation of international experts for solving the most important problems of the power industry is not excluded either. The specialists, consultants-experts are invited to participate in a tender for the construction of a separate power plant or any other units of electrical infrastructure. International water specialists can be invited for elaborating the programmes for the most important problems of the power sector. It is reasonable to submit the relevant problems and programmes relating to the development of the power sector for public discussion in mass media.

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