THE ANALYSIS AND EVALUATION OF THE CONSEQUENCES OF POOR QUALITY POWER SUPPLY FOR CONSUMERS

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ABSTRACT
This report examines issues related to the development of methods of analysis and evaluation of consequences caused by local and system emergencies in the fuel-and-energy complex of this country.

THE QUALITY OF ENERGY SUPPLY AS AN OBJECT OF INVESTIGATION

The main purpose of the functioning of any energy supply systems is to maintain a reliable and good-quality energy supply for consumers. The energy supply quality is a combination of energy supply system properties, which secure the reliability of heat supply for consumers, in the required amounts and of required quality, according to a preset operation mode.
Utilities are supposed to maintain the quality of consumers' supply by securing the rated energy parameters (of the energy agent), within the limits of their operation responsibility and according to the calculated mode (schedule) of delivering energy to consumers. In order to provide this, it is necessary for an energy system to possess sufficient resources for its normal functioning.
The mathematical average of energy distribution should be adopted as the characteristic of energy system functioning quality, meaning energy received by the customer in accordance with his energy load schedule, with the quality indexes remaining within admissible limits. In energy supply systems violations of supply energy quality can be observed in the following forms: 1) as energy supply interruptions or as non-delivery of the requested amount of energy; 2) as supply of energy of improper quality and 3) as a compulsory supply of an excessive amount of energy to the consumer. These disruptions in the form of poor energy quality can be the result of either external or internal factors affecting either some individual elements of the system or the entire system of urban energy supply. The causes that worsen the quality of energy supply can be conventionally divided into objective and subjective ones, into those that depend or do not depend on the operation of utility companies. We find it as necessary to single out the following factors and limitation:

- ✓ natural factors, as Acts of God (earthquakes, floods, etc.) and climatic phenomena in the energy supply area;
- ✓ factors in the form of contingencies (wars, etc.);
- ✓ administrative and financial limitations of energy resources, which are in the possession of the country, a region or a city;
- ✓ technological limitations in the form of insufficient installed capacities of energy sources, throughput capacities of energy systems, due to the state of repair of the networks, etc.

THE POOR QUALITY OF ENERGY SUPPLY AND ITS CONSEQUENCES

Economic consequences caused by the poor quality of energy supply are distributed between all the participants in the process and they can be either positive ones, bringing a certain advantage, or negative ones, which bring about economic losses (create damage). And in every particular case the interests of the participants in the process will not be identical.
Any benefit is, as a rule, connected to the extraction of profit resulting from the sale of extra products, e.g., of fuel or electric energy, when the quality of energy supply worsens. These economic losses should be subjected to analysis as a combination of extra costs linked to the operation mode of the system when it is out of rated limits or due to the poor quality of providing consumers with energy. Therefore, economic results which are due to the poor energy supply quality must be examined in their relation to all individual participants in this process and in accordance with the actual specific conditions.
In the process of making this analysis and evaluation of the economic consequences that are the result of the worsening of the quality of energy supply we must determine losses that are incurred by all the participants in the process and which are due to the poor energy supply quality. The basic components of these losses are as follows:

1) in the energy supply system these will incorporate***:***

- ✓ losses due to insufficient energy delivery and a reduction of the products sale volumes, due to enforced changes of equipment operation modes and an increased product prime cost; also due costs resulting from operations in connection with the finding and elimination of emergencies and the restoration of the normal operation mode of energy supply; losses caused by the repair of damaged equipment and energy lines; payments to cover company constant costs and operators' downtime;

2) inside urban supply systems (for heat supply, water supply and water drainage):

- ✓ losses that are due to falls in the output and rejected products, due to their worsened quality, increased prime costs and reduced profits;
- ✓ expenditures in connection with the elimination of emergencies and their consequences and the restoration of the normal production process;

✓ expenditures to compensate for an insufficient heat supply, when using other energy sources and energy agents;
✓ expenditures related to the supply of water, using land-based transport;
✓ environmental damage caused by the discharge of untreated effluents;
✓ damage caused by other influencing factors;

3) in the area of industrial production:

✓ losses caused by inadequate output and rejected products, by the worsening of products quality, increased prime costs and reduced profits, due to costs in connection with the liquidation of emergency effects and restoration of the normal production mode; expenses to compensate for inadequate amounts of delivered energy due to the use of other sources of energy and energy carriers; losses in connection with constant company costs and operators' downtime; due to the lower competitiveness and solvency; due to damage caused by other consequences;

4) in the area of transportation:

✓ loss of profits and penalties related to interruptions (stoppages) of transport operations; expenses for the evacuation of passengers (securing their survival, due to the provision of other means of transport); expenses in connection with the elimination of emergency consequences and restoration of the normal transportation mode; expenses related to compensations for insufficient energy supplies by using other sources of energy and energy carriers; losses in connection with constant company costs and operators' downtime periods; due to reduced competitiveness and solvency;
✓ Damage due to other consequences;

5) In agriculture:

✓ Losses in connection with the death of animals, due to insufficient products output and rejected products, their worsened quality, increased prime costs and lower profits; expenses in connection with the liquidation of emergency consequences (collection, removal and burial of dead animals) and restoration of the normal production mode; expenses to compensate for insufficient energy supplies, due to the use of other sources of energy and energy agents; losses in connection with constant company costs and operators' downtime periods; losses caused by fires and other consequences; by reduced competitiveness and solvency.

6) in the socio-economic sphere:

✓ death of people, health damage, payments for medical services and sick leave benefits; expenses in connection with compensations for partially undelivered energy due to the use by the population of other sources of energy and energy agents ; compensation for destroyed furniture and lost interior decorations caused by break downs of utility systems in buildings and by fires;

7) in city budgets – this is increased expenses, such as:

✓ increased expenses for the maintenance of infrastructure and housing in cities and towns;
✓ extra expenses for buying fuel, energy and other resources;
✓ subsidies provided for the social care facilities and medical services, for energy supplying organizations and residents; extra expenses for the liquidation of emergency situations; due to reduced tax revenues.

8) in the fuel and energy complex of this country – these are expenses for the production of an additional amount of fuel and energy;

9) in the state budget – additional expenses and losses:

✓ for the liquidation of emergency situations; for supporting the housing and communal services, for the social welfare facilities and medical care; expenses due to reduced hard currency income from exporting energy resources, and others.

Therefore, economic consequences caused by the worsening of the electric power supply quality indicators are not identical for the various participants in this process and these can be characterized by different marks (either plus or minus).

THE INITIAL METHODOLOGICAL PRINCIPLE OF EVALUATION OF ECONOMIC LOSSES DUE TO THE WORSENING OF ENERGY SUPPLY QUALITY

Let us examine and prove the presence of interconnection between the economic and technical parameters, which characterize the quality of energy supply.

Let X_0 – be the vector of calculated (contractual) quality parameters of energy supply, while X_1- will be the vector of the actually maintained quality parameters. If we denote the deviation of energy supply quality parameters from the contract-based level as $\Delta X = X_1 - X_0$, then $X_1 = X_0 + \Delta X$.

Let us assume that the aggregate capitalized value of economic costs in the energy supply system for the case of calculated parameters is equal to $C(X_0)$, while for the actually kept parameters this is equal to: $C(X_1)=З(X_0+\Delta X)$.

The aggregate capitalized value of economic costs in the energy supply system with calculated parameters can be presented in the form of the sum total of economic costs related to all the elements of the energy supply system – from the source of energy down to the end consumer:

$$C(X_0) = \sum_{i=1}^{n} З(X_0)_i \qquad (1)$$

And, accordingly, in case of the actually maintained parameters:

$$C(X_1) = C(X_0 + \Delta X) = \sum_{i=1}^{n} C(X_0 + \Delta X)_i \qquad (2)$$

By factorizing the Taylor sequence into its first derivatives we shall find the costs, when parameters are changed:

$$C(X_1) = \sum_{i=1}^{n} [C(X_0)_i + \frac{dC(X_0)_i}{dX_0} \Delta X] \qquad (3)$$

are a function of the change of quality parameters and, consequently, this means an increase in the economic costs. Therefore, they can be regarded as a function of changes of the quality indexes, i.e.

$$\Delta C = C(X_0 + \Delta X) - C(X_0) =$$

$$= \sum_{i=1}^{n} [C(X_0)_i + \frac{dC(X_0)_i}{dX_0} \Delta X] - \sum_{i=1}^{n} C(X_0)_i$$

and finally:

$$\Delta C = \Delta C(\Delta X) = \frac{dC(X_0)}{dX_0} \Delta X =$$

$$= \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{\partial C(X_0)_i}{\partial x_j} \Delta x_j = \sum_{i=1}^{n} \sum_{j=1}^{m} \Delta C_{ij} \qquad (4)$$

Here ***i =1,…, n*** – is the index of an element in the energy supply system;

j=1, … , m – ditto, of a quality parameter;

X_{oj} - ***j***-th element of quality parameters in the contractual mode;

ΔX_j – a change of the ***j***-th element of a quality parameter;

$\Delta З_{ij}$ – a change of economic costs for the i-th element of the heat supply system, when the the ***j***-th quality parameter is changed.

Thus, the damage or the economic losses caused by the worsening of quality can be regarded as an increase in the economic costs of the energy supply system as a whole, which is due to the changed vector of the energy supply quality parameters. This increase is presented as the sum total of increased economic costs for every quality parameter and for every element of the energy supply system, and in this case not only the technical components of the system, starting from the source to the consumer, should be regarded as system elements, but also those people who are consumers of its services.

CONTROL OF THE QUALITY OF ENERGY SUPPLY

The elaboration of a control system to control the quality of energy supply covers the following issues: rational organization, planning, provision of incentives, supervision and others.

The process of implementation of the various controlling functions can be presented as a decision-making process, which includes the following procedures: 1) alternative (mutually excluding ones) variants of solving problem situations are to be formed up; 2) their preference criteria are to be evaluated and 3) in accordance with chosen criteria decisions are to be taken.

A generalized kind of a characteristic of any decision is its efficiency, which is characterized by the degree of reaching the goals set. The end result of the task to take a decision is a prescription to take actions, aimed at reaching the set goals.

In order to be able to make up a general algorithm to control the quality of energy supply, it is necessary to do the following:

- To determine the structure and mutual links between the individual parts of the system (its elements, aggregate units, units, installations, subsystems);
- To determine the set up of possible actions aimed at preserving the working capacity of the system (switching it off and on, switching on stand-by units, etc.);
- To determine transportation routes for energy delivery, calculating also detour routes and reaching the stage of formulating an energy center energy price;
- To calculate the possible technological consequences of breaks, both for the system itself and its consumers (system switching off, break downs, lack of capacity, changed networks throughput, etc.);
- To assess the entire spectrum of the economic consequences of technological faults for the system itself and its customers (cf. Item.3);
- To determine the results of changes in financial flows for all the levels of the control system hierarchy of the energy system, considering the optimization of expenses related to energy deliveries in cases of technological interruptions in the energy supply system.

Thus, any control of the quality of energy supply consists in following: it is necessary to work out and implement measures which will prevent the emergence of technological faults; to evaluate both technical and economic consequences, when this or that sort of an event takes place; to develop and introduce into actual use a complex of measures aimed at improving the reliability and quality of energy supply for consumers.