Mechanism of adjusting the cost of consumed electricity and the improvement of electricity metering devices necessary for its implementation

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Abstract. The article shows the directions of improving electricity metering devices, including the providing of a mechanism for adjusting the cost of consumed electricity, depending on its quality, the source of distortion and the culprit of distortion. An example of a diagram of a metering device equipped with a function for adjusting the cost of electricity is given.

Keywords: cost of consumed electricity, electricity metering devices

1 Introduction

The most fully accepted methodology for assessing the reliability and quality of the supplied goods and services provided for the organization for the management of the unified national (all-Russian) electric grid and territorial grid organizations is set out in [1] and amendments to it [2]. However, the approach proposed in these documents is not devoid of drawbacks, the main of which is the form of obtaining the initial data - providing it according to the forms proposed by energy companies (at this stage, the information may be distorted).

Automatic data collection is not provided. In particular, the assessment of the quality of supplied electricity is based on an analysis of the number of incoming quality complaints, although not all consumers are able to assess it. Such mechanisms for stimulating energy companies to improve the reliability of power supply and quality of electricity, such as, for example, adjusting the cost of electricity depending on the number of interruptions in power supply and the quality of supplied electricity, are not given.

At the same time, improving the efficiency of power supply systems for consumers requires the development of not only technical devices to improve the reliability of power supply, the quality of supplied electricity, reduce the time for technological connections [3], but also actions to introduce technical and economic mechanisms

that stimulate the implementation of these developments. In turn, the proposed technical means should provide the possibility of implementing technical and economic incentive mechanisms to improve the quality of electricity and the reliability of power supply.

Analysis of existing incentive mechanisms of improving the quality of electricity. Scientists and industrialists have been developing technical and economic mechanisms to compensate for damage caused by low-quality electricity for a long time. So, in the article [4], the mechanisms of economic incentives to maintain the quality of electricity, proposed in the USSR [5, 6], are studied in sufficient details. These mechanisms consist in the payment of compensation payments to the person responsible for the distortion of the quality of electricity. The proposed amount of compensation is 25% of the cost of electricity with a quality that does not comply with regulatory documents. Additional price list No. 09-01-1980 / 11, issued by the USSR State Committee for Prices in 1984, indicates discounts on the electricity tariff for the consumer if the culprit of the electricity quality violation is the power supply company and, on the contrary, the premium to the tariff if the culprit is the consumer.

In [7], discounts / surcharges to the electricity fee are recommended to be set at 12% in case of violation of the electricity quality indicators (EQI). In addition, this work assumes the imposition of a one-time 10% fine of the cost of electricity in violation of the EQI.

These decisions are intended to stimulate an increase in the quality of electricity, but their implementation, in fact, is possible only if technical means are available to record violations of the quality of electricity. Currently, there are electricity metering devices that can monitor electricity quality indicators (EQIs), but they are not used to change the cost of electricity, and do not transmit information about the current quality of electricity to the network manager. There are also technical solutions for the execution of metering devices, involving the imposition of fines on the consumer and the energy supplying organization, given in [8, 9]. Nevertheless, these solutions have not yet found practical application, since a rather serious study of the legal issues of their use is required. The methods for determining the sources of distortion of the EQI are also imperfect, which can lead to incorrect imposition of penalties and further litigation between the consumer and the power supply organization. In addition, an acceptable method for adjusting the cost of electricity is required depending on its quality and source of distortion.

In [10] such a technique is proposed, and in [11] it is corrected taking into account GOST 32144-2013 [12]. Fig. 1 shows a structural diagram of an electricity metering device has been developed that implements the specified method of adjusting the cost of electricity depending on its quality and the culprit of distortions [13].

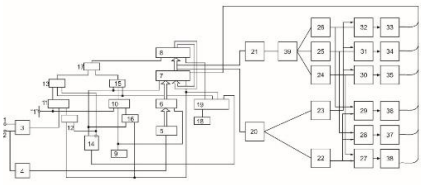

Fig. 1. Structural scheme of a metering device that implements the methodology for adjusting the cost of electricity depending on its quality.

The metering device contains current input voltage terminals 1 and 2, counter inputs 3, input of converter 4, information input of analog-to-digital converter 5 (ADC), information input of register 6, digital memory unit 7 (DMU), information input of counter 8 pulses (CP) , sample pulse generator 9 (SPG), register write control input 6, clock input of the first D-flip-flop 10, information input of the second D-flip-flop 11, element And 12, element And 13, inverse output of SR-flip-flop 14, element And 15, element AND 16, element OR 17, pulse generator 18 (PG), distributor 19

pulse distributor 19 (PD), distortion source control unit BKII 20, distortion level control unit BKUI 21, block for fixing the fact of distortion of the power quality indicator by electric consumer EP 22, fixing unit the fact of distortion of the power quality indicator by the power system ES 23, blocks for monitoring the level of distortions 3ur. - Level 24, 2 - 25, 1 level. - 26, with elements I 27, I28, I29, elements I 30, I 31, I32, blocks that introduce a multiplying factor PK 33, PK 34, PK 35, or a reduction factor PK 36, PK 37, PK 38, time determination unit distortion of power quality indicators 39. The principle of operation of the meter is described in detail in [13, 14], therefore, this article is not considered. We only note that the device provides the possibility of storing and transferring data, as well as displaying information about the amount of consumed electricity, its cost, tariff, increasing (decreasing) coefficient, type and level of distortion, time of distortion of power quality indicators, data transmission, history accounting.

The technique implemented with the use of the metering device described above is not without its drawbacks, namely, that it involves the online adjustment of the electricity cost, which is not quite convenient when calculating the consumer for electricity and is rather difficult to implement.

2 Methodology

The proposed incentive mechanism to improve the quality of electricity and the reliability of power supply. New requirements for metering devices. Therefore, the following mechanism is proposed to stimulate consumers and the energy supplying organization to improve the quality of energy efficiency. It is assumed that the culprit for the distortion of the EE will be paid compensation for violations of the EE quality. But, unlike the methodology discussed above, compensation payments will be determined for a given billing period, for example, for a year or a month. The amount of the compensating payment is proposed to be determined taking into account the sig-

nificance of the distortion of the PQE for a specific type of consumers, which is associated with the unequal damage from the distortion of the PQE for different consumers.

Compensation payment (eq.1) in case of power quality mismatch Kp(t1…t2) in the quality of electricity appears when the deviation of the parameters of the quality of electricity exceeds the values regulated by GOST [12] and includes the costs incurred by the energy supplying organization in the event that the distortion of the quality of electricity occurs through its fault.

The compensation payment can be determined:

$$K_p = K_{EQI} \cdot \frac{\sum(W_i \cdot \Phi)}{T_{stlmnt}} \cdot (\sum T_{total} - \sum T_{total.prms}) \quad (1)$$

K_{EQI} - coefficient characterizing the significance of the EQI distortion (in our case, the voltage deviation) for a given type of consumers or for the power supplying organization in the event that the EQI distortion occurred through the fault of the consumer, a dimensionless value; Wi is the volume of electricity consumption by the consumer for the intervals of the billing period, with the corresponding value of the electricity tariff, kW · h; Φi is the value of the electricity tariff, rubles / kWh; T_{stlmnt} - time of the settlement period, h (for example, year, 8760 h, or month, 672 ... 744 h); $\sum^{n}_{1}T_{total}$ - total time of power quality discrepancy for the billing period, h; $\sum^{n}_{1}T_{total.prms}$ - permissible total time of power quality discrepancy for the billing period, h.

In addition to the quality of electricity, an important factor in the efficiency of power supply is compliance with the requirements for reliability of power supply. Interruptions in power supply can be caused by various reasons, have different duration, but always harm consumers [15, 16, 17, 23], therefore, in case of exceeding the contractual values of interruptions in power supply, economic incentives should also be carried out, in this case, energy supplying organizations, to increase reliability. The implementation of the compensation mechanism in this case should be similar to the above, but in this case, requirements are imposed on the meter to control the reliability of the power supply.

Modern meters are equipped with the ability to fix time intervals when there was no voltage at the point of their connection. However, this data cannot be used as information on the duration of power outages, as it is not clear what caused the lack of voltage. To do this, it is required to equip them with the ability to monitor the voltage at a point up to the input switching device. Such solutions are considered in [18]. This will allow you to control the main indicator of the reliability of power supply - the time of interruptions in the supply of electricity and, if the permissible value of this time is exceeded, automatically determine the amount of compensation [15]. Compensation, as in the case of power quality, should be determined considering the significance of power outages for specific consumers. At the same time, to stimulate consumers to pay for electricity on time, metering should be carried out on a pay-and-use basis, as is done in mobile communications. That is, payment must be made in advance, a consumer account must be formed where he invests. In the absence of funds on the account, the supply of electricity is automatically terminated (or limited depending on the contractual conditions, consumer reliability category).

3 Results

Therefore, new additional requirements are formed for the electricity metering device:

- the ability to receive online data on tariff changes;
- fixing the volumes of electricity consumption at different tariff values;
- power quality control and fixation of time intervals with violations of the EQE;
- the possibility of investing in the counter of the EQE distortion significance factor;
- determination of the culprit of distortion;
- formation of the amount of compensation payments for violations of the EQE;
- monitoring the duration of power supply interruptions;
- the possibility of investing in the counter of the significance coefficient of interruptions in power supply;
- formation of the amount of compensation payments for violations of the reliability of power supply;
- payment for electricity on a pay-and-use basis.

The active development of technologies and means of data transmission, electricity metering, automation and intellectualization of electrical networks [19, 20, 21, 22] suggests that the implementation of the proposed functionality of electricity meters is quite possible and necessary for the transition to the fourth technological mode of the economy.

4 Conclusion

Electricity metering in the context of the digitalization of the economy should be carried out using the capabilities of monitoring the quality of electricity and the reliability of electricity supply. In the event of a violation of the quality of electricity, the culprit of the distortion must make compensatory payments, which must be determined considering the significance of the distortion. Likewise, if the reliability of the power supply is violated, the damage incurred by the parties to the power supply agreement must be compensated. This creates new requirements for metering devices, which must ensure metering of electricity, considering the fulfillment of contractual conditions by the parties.

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