

ECONOMICAL ASPECTS OF ELECTRICAL ENERGY SUPPLY RELIABILITY IN INDUSTRY

Lukáš Prokop, Zdeněk Hradílek, Zdeněk Medvec
VŠB – Technical University of Ostrava, FEI, Department of Electrical Power Engineering
tř. 17 listopadu 15, 708 33, Ostrava - Poruba
Czech Republic
lukas.prokop@vsb.cz, zdenek.hradilek@vsb.cz, zdenek.medvec@vsb.cz

ABSTRACT

In this article, results of the analysis of structure and amount of costs due to power supply interruptions are presented. At present, many possibilities of classifying, separating, or evaluating damages related exist; to the most common, possibilities given below belong. In the first case, these damages can be divided into the damages that are suffered by power suppliers and the damages that are suffered by power customers. Another possibility is the division into damages occurring immediately (directly) after power supply interruptions and damages occurring only after certain time (indirect) periods after power supply interruptions. With reference to the variety of industries, in each branch of industry specific types of damages typical of this branch exist. For simplicity, the damages that occur on the side of suppliers can be expressed as the sum of loss due to unsold power and costs of power supply restoration. On the other hand, the damages on the side of power customers must be analyzed in more detail owing to specifics of individual branches of industry. In this article, merely results of the analysis of damages suffered by customers are presented.

KEY WORDS

Outage costs, Energy not Supply, Function of damages

1. Introduction

In the first part of damage analysis suffered by customers, we must determine types of outages that may occur with the specific customer from the point of view of outage duration. The outage duration should be considered in connection with customer's equipment so that the outage types may be different from each other from the point of view of the extent of equipment affected. These types of outages must be determined in cooperation with technologists and power engineers of the given customer. On the basis of this division of outages, to each type of outages those relevant pieces of equipment which are affected by the given type of outage should be related. The next part of analysis is the identification of technical effects of outage, i.e. the determination of influence of the given outage on the product, or on a piece of equipment. The last step of this analysis is the determination of

economic effects of these technical influences. Here, direct cooperation with economists or workers of controlling of the given industrial customer is needed.

2. The General Expression of Outage Costs

In consequence of power supply interruption, damages occur on the side of supplier as well as on the side of customer.

$$C_{TOTAL} = C_{CUSTOMER} + C_{SUPPLIER} \quad (1)$$

2.1 The Analysis of Damages Suffered by the Customer

As the basic division of damages on the side of customers, the following division into two groups can be regarded:

1. direct damages suffered by the customer – damages occurring immediately after interrupting the power supply (at the beginning of outage).
2. indirect damages suffered by the customer – damages that may happen in the course of outage, or after power supply restoration.

$$C_{CUSTOMER} = C_{DIRECT} + C_{INDIRECT} \quad (2)$$

2.1.1 Direct Costs Incurred by the Customer due to the Outage

Direct costs incurred by the customer can consist of several basic items. These partial direct costs incurred by the customer can be expressed by the following relation

$$C_{DIRECT} = C_{DP} + C_{WI} + C_{RP} + C_{LP} + C_{APL} + C_{PEN} + \sum C_I \quad (3)$$

Where C_{DP} - costs of damaged products, C_{WI} - costs of waiting time of employees, C_{RP} - costs of the restoration of production, C_{LP} - costs arising from lost production, C_{APL} - costs of the alternative to production lost, C_{PEN} - costs of penalty payment, C_I - other relevant direct costs specific of the given customer.

Relation (3) can be modified (extended) if applied to real industrial conditions due to different damages in different industrial branches.

Costs of the Restoration of Production

Among the costs of production restoration, the costs of restoration of whole production equipment if damaged in the course of outage and the costs of equipment restarting can be ranked. The costs of production restoration can be expressed by a relation as follows

$$C_{RP} = C_{COR} + C_{START} \quad (4)$$

where

C_{COR} - costs of production equipment correction, C_{START} - costs of equipment starting.

Costs of the Alternative to Production Lost

In case that the outage does not affect the whole premises of the plant (e.g. in case of power supply to a part of the premises from another source), it is possible that the customer will maintain production by securing (buying) some parts, half-finished products or services from another producer (supplier).

Costs of Penalty Payment

In the industrial environment, all supplies are usually secured on the basis of contracts; the contracts usually include clauses regarding penalization, or allowances in case that the producer is not able, for various reasons (production failure due to an interruption in power supply to the production plant), to supply the goods. The total amount of costs of penalty payment depends on many factors, and the main factor is mostly the period of delay in delivery (here, a relation between the delay in delivery and the duration of outage is obvious in case that production equipment is utilized fully (100%) and the manufacturer uses make-to-stock production).

Indirect Costs Incurred by the Customer due to the Outage

Total indirect costs incurred by the customer can be expressed as a sum of individual partial indirect losses as follows:

$$C_{INDIRECTC} = \sum k_{IC} \cdot C_{IC} \quad (5)$$

Coefficients k_{IC} express a possibility that the damaged customer can decrease the total costs, e.g. by putting emergency plans prepared in advance into operation. The more detailed specification of indirect costs incurred by the customer is very complicated and in the majority of cases, only professional estimates are done. That is why we do not consider any indirect costs in our analyses at present.

Total Costs Incurred by the Customer

Total costs incurred by the customer can be expressed by inserting relation (4) into relation (3), and subsequently modified relation (3) and relation (5) into relation (2). Thus we shall obtain the resultant relation for the total costs incurred by the customer in the following form

$$C_{CUSTOMER} = C_{DP} + C_{WI} + C_{COR} + C_{START} + C_{LP} + C_{APL} + C_{PEN} + \sum C_i + \sum k_{IC} \cdot C_{IC} \quad (6)$$

C_{DP} , C_{WI} , C_{COR} , C_{START} , C_{LP} , C_{APL} , C_{PEN} are functions of many variables and their mathematical expression is difficult. However, we can simplify the situation by regarding these functions as functions of a single variable, namely the duration of outage.

3. Practical Applications of Theoretical Relations

We applied the above-presented theoretical relations to an industrial enterprise in the real environment. The basic assumption was the maximum utilization of the observed production line, which was fulfilled. The enterprise does not carry out make-to-stock production, but all manufactured goods are sold immediately. The analyzed company is concerned with aluminium processing.

Into the analysis, hypothetical situations can be included as well. Different types of interruptions have different technical-economic effects; it follows from this that the analysis must be done for each type of outage individually.

4. Conclusion

In this article, results of theoretical analysis of costs due to the outage suffered by the customer are summarized. These theoretical relations are general and universal. The reason is the specificity of each industrial branch, it means that partial costs incurred by individual industrial enterprises as well as industrial branches are different.

The customer can use the results of this analysis for planning investments to improve the reliability of power supply, as a basis for making an insurance against unplanned losses, etc.

Acknowledgements

This article was prepared in the frame of research within the project AV-CRT 100300414.

References

- [1] L. Prokop, Estimation of Energy not Supply. A tutorial review, *Proc. WOFEX 2005*, Ostrava, Czech Republic, 2005, 141-146
- [2] L. Prokop, Z. Medvec, Ocenění nedodané energie – stanovení nákladů na výpadek při přerušení dodávky elektrické energie, *Proc. The 3rd International Scientific Symposium ELEKTROENERGETIKA 2005*, Košice, Slovak Republic, 2005
- [3] J. Mertlová, Vliv nedodávky elektrické energie na odběratele, *Proc. Aktuální otázky a vybrané problémy řízení elektrizačních soustav*, Poděbrady, Czech Republic, 2005
- [4] R. MALAMAN, Second Benchmarking Report on Quality of electricity supply [on-line]. *Council of European Energy Regulators, Working Group on Quality of Electricity Supply*, http://www.autorita.energia.it/inglese/eng_index_pub.htm, 2003