

HOW THE CUSTOMERS PERCEIVE THE PROBLEM OF VOLTAGE QUALITY

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ABSTRACT

This paper describes the problem of power quality from side of customers. The survey is based on the complaints regarding voltage quality (VQ) obtained in years 2007-2010. These complaints were evaluated and main problems of customers with power quality were detected. In additional survey the complaints of low voltage (LV) customers were evaluated separately for connection from overhead line or from underground cable.

INTRODUCTION

Liberalization of the electricity market brings considerable pressure to introduce penalties for insufficient voltage quality parameters. These penalties should be the nature of the rebate payments for electricity, in case of poor voltage quality. In the Czech Republic, the legislative framework for voltage quality is established by the following legislation:

- Energy Act No.458/2000 Coll. [1], which imposes the electricity distributor's obligation to comply with the voltage quality parameters specified in the implementing regulation
- This regulation is Decree No. 540/2005 Coll. [2], which defines, in Section 8, the voltage quality standard as voltage variations and frequency in line with the requirements of standard EN 50 160 [3]

The above-mentioned legislative documents stipulate the following obligations for the electricity distributor:

- Settle customer complaints concerning voltage quality within 60 days of receipt. Otherwise, the customer is entitled to a compensation of approximately EUR 1,000
- In case of a justified complaint concerning voltage quality, the electricity distributor is obliged to remove the causes of lower voltage quality within a specific period of time; otherwise the customer is entitled to a compensation of approximately EUR 2,000

Beyond the framework of these statutory obligations, the distributors in the Czech Republic grant, to customers supplied from the LV distribution network, a discount on the price of electricity distribution in the form of waiver of a monthly payment for power input based on the nominal current value of the circuit breaker upstream of the electrometer in case of a justified complaint concerning voltage quality.

COMPLAINTS

The customer expresses its dissatisfaction with the voltage quality by means of a claim or complaint against voltage quality. These are systematically recorded and evaluated in E.ON Czech Republic. The subject of evaluation includes complaints regarding voltage quality obtained in years 2007-2010.

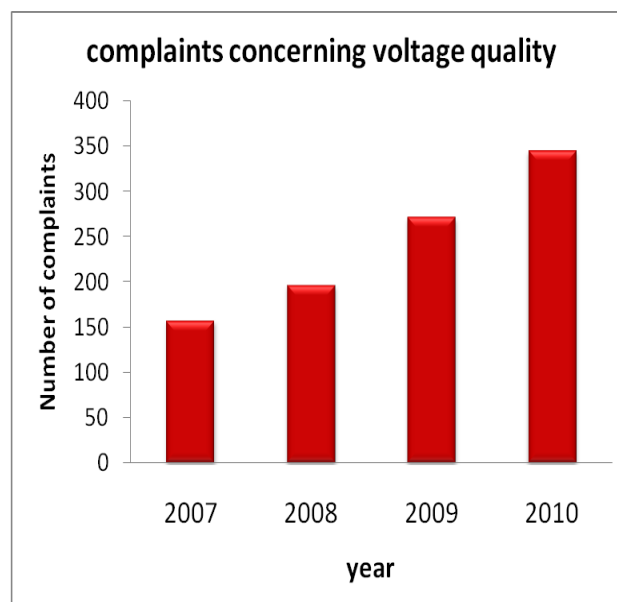


Fig. 1: number of obtained complaints regarding VQ

Figure 1 clearly shows that the number of complaints regarding voltage quality has been growing year on year. The supply territory of the company E.ON in the Czech Republic accounts for approximately 1.5 million customers. The most of these customers are supplied from LV voltage level. The growing number of complaints regarding voltage quality can be explained so that the customers expect a higher quality in connection with the growing payments for electricity distribution. They express any dissatisfaction with its quality through complaints.

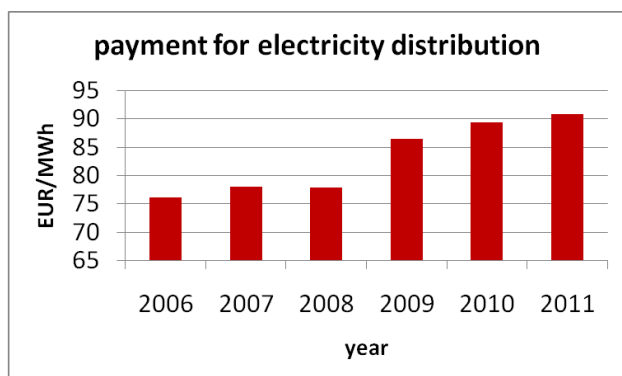


Fig. 2: price of electricity distribution for an exemplary rate D02d, LV customer, household with ordinary types of electrical appliances where electricity is not used for heating and hot water

Of course, it is necessary to add the price of electricity supply (approx. EUR 70 per MWh in 2011, examples of rates as in figure 2) to the total price of electricity, in addition to the price of distribution as shown in figure 2.

In the last 2 years, electricity distributors in the Czech Republic face an enormous interest in the connection of photovoltaic power plants. The mass operation of generating plants also results in poorer voltage quality parameters in the distribution network. The operation of each power plant, including a small one, increases the voltage values in the place of connection to the distribution network. In case of accumulation of sources in one part of the distribution system, it is possible that overvoltage will occur, or that the voltage variations will not comply with the requirements of standard EN 50160. In addition, complaints regarding voltage quality are often submitted directly by power plant operators, e.g. for reasons of spontaneous inverter disconnections in photovoltaic plants.

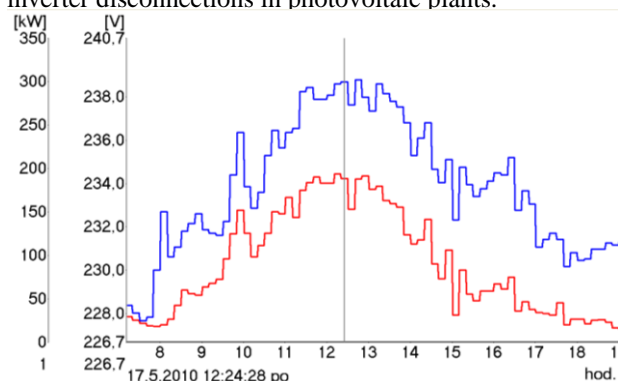


Fig. 3: voltage variations (blue) in the place of connection of a photovoltaic plant to the LV distribution network depending on the supplied plant power (red), phase L1

Cause of complaints

All obtained complaints were evaluated from view of cause which describes the customer. The goal of the survey was to identify the causes of poorer voltage quality that most often result in customer complaints. Table 1 clearly shows that the most frequent cause of poor voltage quality is voltage fluctuation, which can result in visual continuous flicker.

While phenomena such as voltage fluctuation, voltage sags and supply interruption are observable by unskilled customers, for the other phenomena listed in Table 1 the customer infers the low quality on the basis of other indicators (non-functioning or poorly functioning electrical appliances, electrical appliance failures).

cause of complaint	% of complaints
voltage fluctuation	33
overvoltage	15
voltage sags	13
supply interruption	13
voltage quality	11
low voltage	10
other	6
total	100

Tab. 1: cause of all obtained complaints in years 2007-2010

Evaluation of complaints

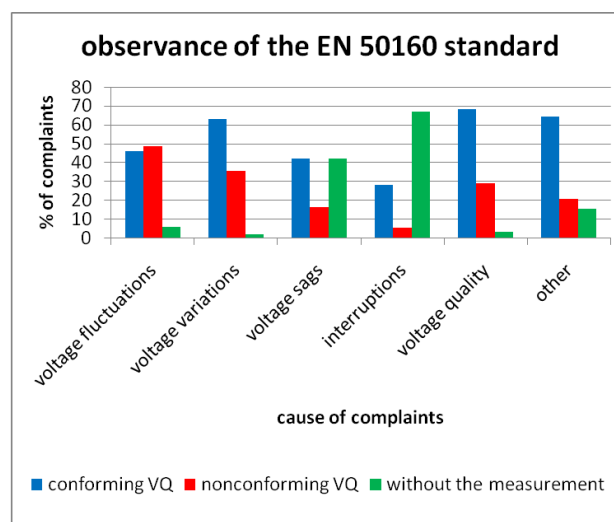


Fig. 4: evaluation of complaints according to the standard EN 50160 (all complaints obtained in years 2007-2010, evaluation of all the VQ parameters), item "voltage variations"="overvoltage"+"low voltage"

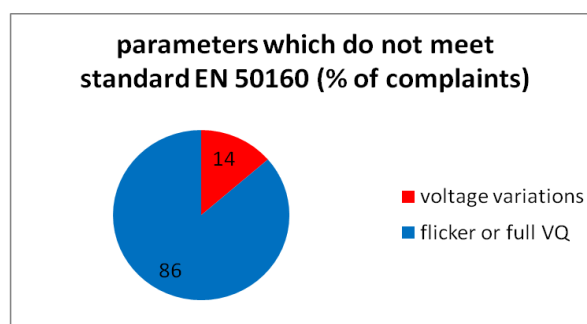


Fig. 5: VQ evaluation of complaints concerning only voltage variations (complaints obtained in years 2007-2010)

In most cases it is necessary, in case of a customer's complaint regarding voltage quality, to perform a measurement in the customer's supply terminal and to evaluate it in accordance with the requirements of standard EN 50160. Figure 4 shows that the highest share of nonconforming voltage quality according to standard EN 50160 accounts for complaints regarding voltage fluctuation. It is also possible to evaluate compliance with the requirements of standard EN 50160 from all complaints without any differences in the cause of complaint, see Fig. 6.

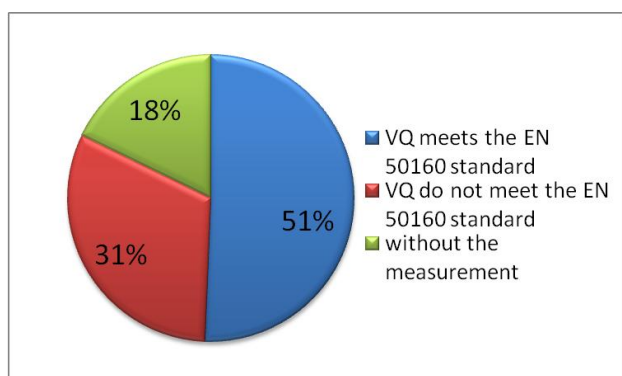


Fig. 6: evaluation of complaints according to the standard EN 50160 (all complaints obtained in years 2007-2010)

Figure 6 shows that in case of 31% of all received complaints, the voltage quality did not conform to the requirements of standard EN 50160 based on the performed measurements. In case of some complaints, measurements were not carried out - for example with respect to complaints regarding the specific voltage sag that resulted in the failure of power equipment.

Let's also analyze specific VQ parameters, where, if exceeded, VQ in case of obtained complaints did not conform to the requirements of standard EN 50160 – see Tab. 2.

VQ parameter	% of measurements
Flicker	21
voltage variations	3
voltage variations and flicker	7
without the measurement	18
VQ meets requirements of the EN50160 standard	51
Total	100

Tab. 2: VQ parameters which do not meet requirements of the EN 50160 standard, evaluation of all complaints regarding VQ obtained in years 2007-2010

Table 2 clearly shows that in 21% of all cases, only the flicker parameter was exceeded. Excessive flicker parameter and nonconforming voltage variations were recorded in 7% of cases. Cumulatively, an excessive flicker parameter was therefore recorded in 28% of all cases. Only nonconforming voltage variations were recorded in 3% of all cases, i.e.

cumulatively, together with an excessive flicker parameter, in 10% of all cases. In 51% of all complaints regarding voltage quality, conformity with the requirements of standard EN 50160 was demonstrated. It can be also concluded that about every other VQ measurement due to a voltage quality complaint does not conform to the requirements of standard EN 50160, but only 10% of all measurements do not conform for parameter voltage variations. It can be also quantified that prior to the introduction of distributed production in the LV distribution network, voltage variations under EN 50160 were not a serious problem, and it will be interesting to watch how renewable energy resources will influence this development.

VOLTAGE QUALITY OF LV CUSTOMERS, WAY OF CONNECTION

Complaints regarding voltage quality of low voltage customers were evaluated separately for connection from underground cable or from overhead line.

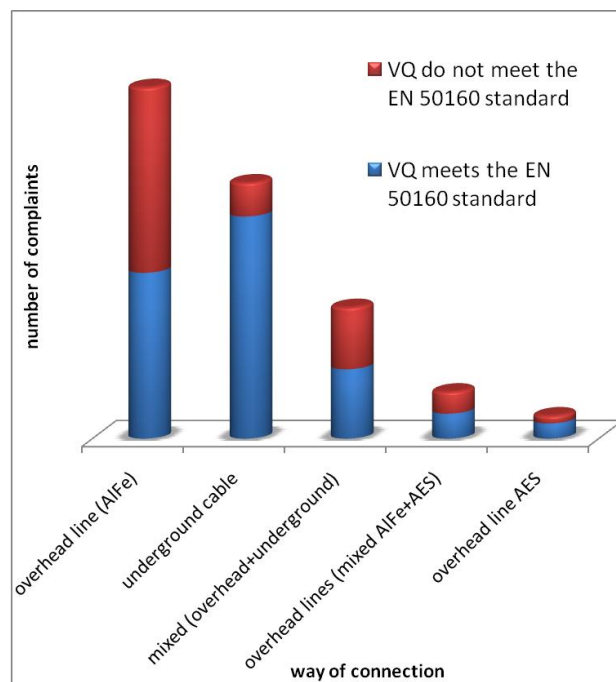


Fig. 7: VQ and way of connection of LV customers

Figure 7 shows that the lowest share of nonconforming voltage quality according to requirements of standard EN 50160 was recorded among customers supplied from the low voltage distribution network in case of connection using an underground cable. Voltage quality is closely related to the value of the parameter of short circuit power in the place of connection. A cable, usually with a cross-section greater than an overhead line, more easily transfers higher values of this parameter in the place of assessment. The higher the value of this parameter is, the less likely the voltage quality parameters under standard EN 50160 are to be exceeded.

CONCLUSION

A growing number of complaints regarding voltage quality signal that the issue of voltage quality grows in significance and has to be given appropriate attention. It was proven in the speech that the highest share of customers who complain about voltage quality specify voltage fluctuation as the cause. Voltage fluctuation usually causes the negative visual impression of flicker. It was also proven that about 31% of measurements due to complaints regarding voltage quality do not conform to the requirements of standard EN 50160, see Fig. 6. The most frequent cause of poor voltage quality is that the flicker parameter is exceeded. The lowest share of justified complaints, in terms of standard EN 50160, was demonstrated among customers who are connected by underground cable to the LV distribution network. The technical design of the distribution network has a huge influence on the perception of voltage quality among customers. It is also a question how voltage quality will develop in the LV distribution network due to the operation of a growing number of power resources. The experience of electricity distributor shows that the number of LV networks with nonconforming VQ will grow due to operation of the disperse resources. The goal of electricity distributors and CEER should be to direct the investment cost into appropriate areas in a thoughtful and targeted manner so that the customers could obtain maximum benefit from the specific volume of investment. Based on the presented data observed by the customers, voltage fluctuation (continuous flicker) is demonstrably considered as the biggest problem, with a 33% frequency of complaints (see Tab. 1) and with the highest probability of success of a justified complaint (approx. 49%), see Fig. 4. The problem of voltage variations has a 25% frequency of complaints (see Tab. 1) and was demonstrated only in 14% of complaints concerning voltage variations (overvoltage or low voltage), see Fig. 5. Nonconforming voltage variations were demonstrated only in 10% of all complaints, see Tab. 2. This shows that 90% of all customers' problems are due to a different cause than voltage variations and the investments in this area will be appreciated only by $25\% * 14\% * 0.01 = 3.5\%$ of customers, where the actual cause of the customers' problem is really voltage variations. It shows that is not possible to make decisions in this area without a truly rational, technical and economic analysis.

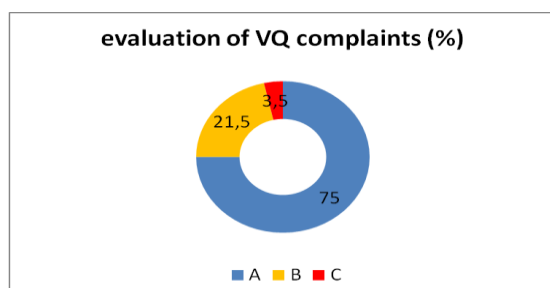


Fig. 8: evaluation of complaints regarding VQ

Legend (Fig. 8):

A+B+C: all complaining customers (100%)

B+C: complaints regarding voltage variations (25%)

C: justified complaints regarding voltage variations (3,5%)

Acknowledgments

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- [2] Decree No. 540/2005 Coll. on the quality of power supply and related energy services, Energy Regulatory Authority, Czech Republic
- [3] EN 50160 Ed.3 Voltage characteristics of electricity supplied by public distribution systems. Brussels: European Committee for Electrotechnical Standardization, 2010