ENERGY REGULATORS REGIONAL ASSOCIATION

ERRA Case Study
Supply quality regulation in the energy industry – Hungarian case study with European outlook

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NEW SZÉCHENYI PLAN

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ENERGY REGULATORS REGIONAL ASSOCIATION

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CASE STUDY:

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Hungarian case study with European outlook**

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TABLE OF CONTENTS

1. The regulator's motivation to regulate supply quality

Customers expect to get an appropriate quality of service in exchange for their paid bills. Quality is made up of a number of different quality factors. In electricity supply, these factors include customer service issues, commercial relationships, continuity of supply, voltage quality, and others. Each customer has a different perception of quality; some quality factors can be objectively measured, while others cannot. One means of protection of consumers is the measurement and control of quality of supply. The Hungarian regulator carries out the complex and extensive task of consumer protection not only by investigating consumer complaints, but also by determining quality requirements for the distribution and supplier activity of the licensees and by introducing an incentive scheme, which demands the companies to provide continuous improvements in their performance. The supervision of this required improvement on a regular basis and the possible application of sanctions are also performed by the regulator. [1, 13]

Quality regulation primarily focuses on electricity supply, which is confirmed by the numerous studies issued in this field and the regular benchmarks prepared by the CEER[1] on the European practise of quality regulation. However gas supply has so far received much less attention in relation with quality regulation, consequently there is no extensive European comparison in this field. While the Hungarian regulator has developed some quality requirements for the gas supply as well. The different areas of gas supply and distribution are not regulated to the same extent, as stricter rules (in most cases with financial incentives) are applied for the different form of contacts with customers (e.g. in writing, by phone), for the process of connecting a new customer to the gas distribution network, while in case of supply security of gas distribution system the quality regulation is practically limited to monitoring and data collection. Some specificity of quality regulation of gas supply will be presented later.

In Hungary the electricity distributor companies were privatized in 1995. These companies possessed and still possess a natural monopoly as they operate in assigned regions, consequently a customer who lives in the operational area of one of the DSOs cannot choose another distribution company. This environment requires a certain level of customer protection, which can be performed on one hand by carrying out customer surveys in order to get information on the customers' preferences and on the other hand by monitoring the quality of services the distribution system operator deliver to customers.

Two years later the price-cap regulation was introduced in Hungary. It is stated that privatization increases the profit orientation of the companies, especially when the price cap regulation creates additional incentives for cost reduction (investments, maintenance, personnel) in order to increase efficiency. In such cases importance of monitoring supply quality and setting quality requirement becomes greater in order to prevent any noticeable deterioration in service quality. [15, 16]

While this effect of price-cap regulation was already recognized by the CEER in its 1st Benchmarking Report, two years later in the 2nd BR it was concluded that no relevant signals of quality of supply decrease are emerging in European countries even after utilities privatization, increasing supply competition, price-cap regulation for monopolistic activities and legal unbundling of businesses. [1,2] The importance of quality regulation was highlighted in the next Benchmarking Report, which stated that price-cap regulation without any quality standards or incentive/penalty regimes for quality may provide unintended and misleading incentives to reduce quality levels. Quality incentives can ensure that cost cuts required by price-cap regimes are not achieved at the expense of quality. The increased attention to quality incentive regulation is rooted

[1] Council of European Energy Regulators

not only in the risk of deteriorating quality deriving from the pressure to reduce costs under price-cap, but also in the increasing demand for higher quality services on the part of consumers. For these reasons, a growing number of European regulators have adopted some form of quality incentive regulation over the last decade. Moreover, quality is multidimensional and some aspects of quality have a long recovery time after deterioration. Hence, quality of service is usually regulated over more than one regulatory period to address numerous issues, including continuous monitoring of actual levels of performance. [2,3]

In Hungary the first sign of any deterioration in the performance was observed in 1998-1999. The outage rate[2] has been significantly increased at most DSOs, therefore monitoring and regulation of quality of supply became extremely important. The importance of this issue was confirmed and the effective performance of the task it involves was supported when the regulator was authorized by the Act on Electric Energy in 2003 to issue regulatory resolutions on quality of supply.

[2] Outage rate is the ratio of energy supplied to available energy

2 Introduction of a new regulation – the process of formulating new regulations

Authorization was given to the regulator in 2003 by the Act CX of 2001 on Electric Energy and, by Act XLII of 2003 on Natural Gas to measure service quality, collect quality data, set requirements and enforce the licensees to meet these requirements.

According to the Government Decree 273/2007. (X. 19.) on the implementation of certain provisions of the Act LXXXVI of 2007 on Electric Energy (hereinafter: Government Decree 273/2007) [18]:

"For the protection of customers the regulator shall determine quality indicators, including minimum quality requirements and expected quality levels for the licensees to be met by both on system level and on individual customer level. The regulator is authorized to entrust independent experts with measuring the level of customers' satisfaction and the level of quality of electricity supply the licensees are expected to deliver." [3]

According to the provisions of the Act LXXXVI of 2007 on Electric Energy and the Act XL of 2008 on Natural Gas: [17,20]

„The Office[4] shall determine minimum quality requirements and expected levels of performance for the licensees' activity in regulatory resolutions.

The scope of quality indicators shall cover the followings:

- *Reliability of supply*
- *Continuity of supply*
- *System reliability*
- *Consumer contacts*
- *Measureable and verifiable characteristics of voltage quality/gas quality*
- *Service quality of other activities related to the core activity of the licensee.*

The Office is entitled to define quality requirements to be met by the licensees separately for individual customers and for the whole population and also to impose sanctions in case the licensee fails to provide the required quality level.

The resolution paragraph shall include

- *a) the deadline for the licensees' data reports and the requirements for the content and the reliability of data reported,*
- *b) the sanctions to be applied in case of non-compliance with the requirements*
- *c) the indicators with and without the option of sanctioning."*

The Government Decree 273/2007 also defines rules for the procedure of introducing a new regulation as follows [18]:

"The regulator shall make all draft regulatory resolutions publicly available on its website therefore the opportunity is given for 30 days to anyone interested in making comments on the draft. If according to the comments received it is considered necessary, the regulator initiates discussion with participation of representatives of the licensees and of the customer organizations, by which the comments were taken. After the consultations the regulatory resolutions shall be issued under a public administration procedure initiated by the regulator, in which the licensees are involved as clients."

[3] Please note that the provisions of the law described here are the results of unofficial translation.
[4] Hungarian Energy Office: the predecessor of the Hungarian Energy and Public Utility Regulatory Authority

The Hungarian regulator has experienced the importance of consultation and cooperation with the licensees in the introduction of a new quality regulation. It was especially relevant before authorization was given to the regulator to define quality requirements on the electricity and gas supply. Lacking authorization the regulator did not have any legal basis to define service quality levels and any instrument to force the licensees to comply with them. Hence the regulator has decided to work together with the licensees on improving the quality of services by involving them early in the process of creating new quality requirements instead of just forcing them to implement the outcome of the process. Therefore the licensees and the customer organizations are always given the opportunity to give their comments on the draft regulation and in some cases to help the regulator to define appropriate requirements by providing data on actual performance or by pointing out the potential obstacles (e.g. the average restoration time in case of medium voltage interruptions cannot be decreased below a certain limit (cca. 1,5 hours) without ignoring the standards on occupational safety and health) of meeting the expected quality levels. Thanks to this real conversation between the regulator and the interested parties the final result of the process - a new regulatory resolution – is usually accepted and supported by all parties. The above presented method is an example of how regulators can introduce requirements on the performance of the licensees and to persuade them to comply with them voluntarily without having any legal instrument in its hands. There are some areas of quality regulation where the regulator does not consider it reasonable to issue a regulatory resolution (e.g. the subject does not require such strict regulation or it is considered premature), in such cases the above presented procedure results in a regulatory recommendation. This form of regulation is often used in the Hungarian quality regulation, e.g. voltage quality monitoring activity of the DSOs is regulated in form of a regulatory recommendation. Despite the fact that this kind of regulation does not impose any obligations on the companies it serves as a guideline and in case of careful preparation and continuous cooperation it can be just as effective and can provide with the same results as other stricter regulatory instruments. Of course it is not excluded that sometime the recommendation may be transformed to a regulatory resolution.

Gradual approach is very important when implementing a new regulation. As a first step the regulator shall determine some quality indicators for monitoring, which aims at having real and reliable information on the actual performance of the companies. After some years of observation and data collection – being aware of the current quality level that companies are currently capable to provide with customers – minimum quality requirements or expected quality levels shall be linked to the monitored quality indicators. One should be careful when defining the requirements: if they are too easy to comply with, the company is not motivated to improve its performance, or if they are too strict, they can cause the same effect. If there is a huge distance between the actual performance of the company and the required level of quality, the company may consider that investments (financial and labor input) necessary to meet the requirements can bring the desired results only in the long run, which may question the investment. Another aspect shall be considered when defining requirements: the financial consequences the customers are facing with in return for getting better quality services. If the current environment does not allow the regulator to increase the network charges and consequently the end-user price, then setting stricter quality requirements shall be postponed.

The requirements shall be defined taking into account many factors, like the actual quality levels, the objectives to be achieved and the deadline for achieving the target values. For the timeframe a gradual approach can be very useful from both the licensees' and the regulator's point of view, as companies get time enough to carry out the necessary developments and the regulator can follow-up the progress or on the contrary the lack of any improvements in the companies' performance. In this last case it is possible to intervene and thus avoid the financial consequences. This approach was used by the Hungarian regulator several times; one example is that automatism of compensation payments for Guaranteed standards (presented in detail in Section 3.5) was gradually introduced over three years; another example of gradual approach is that when the regulation on continuity of supply was introduced, a larger scale of improvement was required from the companies, but as they get closer to the target values, the expected rate of improvement has been constantly decreasing (see Section 3.1.1). As a final step the regulator may associate financial incentives with those quality indicators, which are the most crucial from the customers' point of view in order to directly motivate the companies to perform beyond the expectations. Regulators should be careful when choosing quality indicators to be associated with financial consequences, as if the measurement of the actual quality levels is not accurate and reliable enough, it can result in inappropriate penalization.

When formulating a new regulation, the regulator shall choose the regulatory instrument to be applied prudentially. Taking into account the features of the service to be regulated and its impact on the customers, quality requirements may be defined on system level or on customer level. Experiences show that the most effective protection of customers can be accomplished by extending the regulation to the level of individual customers. That is why CEER recommends in its 5th Benchmarking Report that regulators apply guaranteed standards with automatic compensation. At the same time it is also acknowledged that determining requirements on system level (these are the so-called overall standards) results in an adequate level of quality. For those quality indicators, which are the most important from the customers' point of view e.g. connection to the network, CEER believes that a combination of overall standards with economic sanctions and guaranteed standards is recommended, in order to improve the average performances and to protect customers from the worst service conditions. [5]

A periodic review of the regulation is very important taking into account the improvements in the companies' performance with respect to the quality standards set by the regulator as well as the expectations of the customers. It also shall be assessed whether the regulatory instrument actually delivers the desired results. In addition publication of quality data is also recommended for the regulators. It can be accomplished in many ways, e.g. by making the annual reports of the licensees available on the regulators website or by enforcing them to make the reports available on their websites, or by making available the evaluation prepared by the regulator on the supply quality data reported by the companies on the regulators website, or a summary of these reports can be published in the annual report of the regulatory authority. Publication of quality data is a very effective regulatory instrument. The published comparison of performance of the companies and the quality of services they provide for the customers stimulates a competitive environment and encourages the companies to make improvements. [5]

3. Supply quality monitoring and regulation on system level and on customer level

3.1. Continuity of supply

Continuity of supply means the availability of supply. From the customers' point of view the continuous availability is the most important feature of a good quality electricity and gas supply. When the electricity supply is not available, meaning in practice that the voltage at the supply terminals of a network user drops to zero or nearly zero (according to norm EN 50160), this is referred to as an interruption. The fewer and the shorter these interruptions are, the better the quality of supply is from the consumers' perspective. Continuity of supply matters to all type of customers: for large industrial users interruptions of even a relatively short duration can lead to substantial financial losses, whilst for residential customers interruptions can leave people without heating, lightning and cooking facilities [3,4]. Therefore it is an important task for the distribution system operators and the transmission system operators to optimise the continuity performance of their network/system in a cost effective manner. The role of the regulators in a monopolistic network condition is to ensure that this optimisation is carried out in a correct way taking into account the user's expectations and their willingness to pay. [5]

Continuity of supply is monitored in most European countries, although there are some differences in the type of interruptions monitored, in the continuity indicators calculated, in the measurement techniques, in the voltage levels monitored, etc.

In Hungary three types of interruptions are defined according to their duration, which are separately monitored. These are "transient interruptions" ($T \leq 1$ s), "short interruptions" ($1 \text{ s} < T \leq 3$ min) and "long interruptions" ($T > 3$ min). Interruptions can be planned and unplanned interruptions. Planned interruption is an interruption when the affected customers get a notification in advance, and all other interruptions are classified as unplanned interruptions. The interruptions of the networks at all voltage levels are monitored.

Before the restructuring and privatization in Hungary the state owned power supply companies monitored, collected and evaluated data and information related to the reliability of network elements, mainly in order to find the need for increased interventions by the operational and maintenance personnel, and for development. After the privatization of supply/distribution companies in 1995 the regulator introduced quality regulation on supply security of medium and high voltage networks. The main principle of quality of supply regulation was to continue the collection of breakdown records of medium and high voltage network and as historical data was available, it became possible to compare the performances in the new circumstances to the ones prior to the privatization. The regulator experienced that consumers shows less interest in breakdowns and outages of transmission lines and network equipment, but are much more sensitive to such characteristics that impede or limit their energy supply. Then the regulator decided to include such indicators in the quality regulation of supply which enables the assessment of breakdowns from the point of view of the consumers. After careful cooperation with utilities the data collection began in 1998. As there were no records on the number of consumers affected by interruption, a calculation methodology was agreed with power utilities in order to start the determination of the indicators of continuity of supply and parallel to it a correct recording method was developed step by step at the utilities. [13,16]

The first regulatory resolution on the continuity of electricity supply was issued in 1998. In 2005 the regulation of these two areas – supply security of medium and high voltage networks and the continuity of supply – were merged into one regulatory resolution and since then it has been serving as a basis. The requirements of the regulatory resolution aim at incentivising the DSOs to improve the security and continuity of electricity supply in order to approach the more advanced European quality levels in the long term. Further objective was that the DSOs assure secure and continuous operation of the network elements, therefore ensuring the availability of the network infrastructure for the market-oriented electricity trading.

A) The regulatory resolution defines the following quality indicators for monitoring and reporting concerning the continuity of electricity supply [5]:

A)1/h. Average number of long unplanned interruptions: is the average number of times per year that a customer is affected by a long unplanned interruption. It is expressed in number of interruptions/number of consumers/year. This indicator is commonly known as SAIFI.

$$C_K^h = \frac{\sum_{i=1}^{n} f_i^h}{F}$$

f_i^h : number of customers affected by each unplanned interruption

F : total number of customers

A)1/t. Average number of long planned interruptions: is the average number of times per year that a customer is affected by a long planned interruption. It is expressed in number of interruptions/number of consumers/year.

$$C_K^t = \frac{\sum_{j=1}^{m} f_j^t}{F}$$

f_j^t : number of customers affected by each planned interruption

A)2/h. Average duration of long unplanned interruptions: is the average amount of time per year that a customer is affected by a long unplanned interruption. It is expressed in the duration (min.) of interruptions/number of consumers/year. This indicator is commonly known as SAIDI.

$$C_T^h = \frac{\sum_{i=1}^{n} f_i^h \times t_i^h}{F}$$

t_i^h : restoration time of each unplanned interruptions

A)2/t. Average duration of long planned interruptions: is the average amount of time per year that a customer is affected by a long planned interruption. It is expressed in the duration (min.) of interruptions/number of consumers/year.

$$C_T^t = \frac{\sum_{j=1}^{m} f_j^t \times t_j^t}{F}$$

t_j^t : restoration time of each planned interruptions

[5] Indicators A)1/h., A)1/t., A)2/h., A)2/t., A)3/h and A)3/t are calculated cumulatively for all voltage levels and separately for LV, MV and HV networks. Indicators A)4/a., A)4/b., A)5/a. and A)5/b. are calculated both separately for LV and MV networks and cumulatively for these two voltage levels. A)6/a. and A)6/b. indicators are only applicable to MV networks. B)1. indicator is calculated cumulatively for all voltage levels, B)2. and B)3. are applicable only to MV networks and B)4. refers to HV networks.

A)3/h. Average duration of long unplanned interruptions relative to the number of affected customers: is the average duration of long unplanned interruptions relative to the number of customers affected by at least one unplanned long interruptions. It is expressed in the duration (min.) of interruptions/number of affected consumers/year.

$$C_t^h = \frac{\sum_{i=1}^{n} f_i^h \times t_i^h}{\sum_{i=1}^{n} f_i^h}$$

A)3/t. Average duration of long planned interruptions relative to the number of affected customers: is the average duration of long planned interruptions relative to the number of customers affected by at least one planned long interruptions. It is expressed in the duration (min.) of interruptions/number of affected consumers/year.

$$C_t^t = \frac{\sum_{j=1}^{m} f_j^h \times t_j^h}{\sum_{j=1}^{m} f_j^h}$$

A)4. Restoration rate of unplanned interruptions:

- A)4/a: proportion of customers supplied within 3 hours: $$A^3 = \frac{\sum_{i=1}^{n3} f_{\text{üi}}^{k3}}{\sum_{i=1}^{n} f_i^k}$$
- A)4/b: proportion of customers supplied within 18 hours: $$A^{18} = \frac{\sum_{i=1}^{n18} f_{\text{üi}}^{k18}}{\sum_{i=1}^{n} f_i^k}$$

$f_{\text{üi}}^{k3}$: number of customers supplied within 3 hours after an unplanned interruption

$f_{\text{üi}}^{k18}$: number of customers supplied within 18 hours after an unplanned interruption

f_i^k : number of customers affected by each unplanned interruption

A)5. Restoration rate of planned interruptions:

- A)5/a: proportion of customers supplied within 6 hours: $$A_T^6 = \frac{\sum_{j=1}^{m6} f_{\text{üj}}^{k6}}{\sum_{j=1}^{m} f_j^k}$$
- A)5/b: proportion of customers supplied within 12 hours: $$A_T^{12} = \frac{\sum_{j=1}^{j12} f_{\text{üj}}^{k12}}{\sum_{j=1}^{n} f_j^k}$$

$f_{\text{üj}}^{kk63}$: number of customers supplied within 6 hours after a planned interruption

$f_{\text{üj}}^{k12}$: number of customers supplied within 12 hours after a planned interruption

f_j^k : number of customers affected by each planned interruption

A)6. Average number of transient and short interruptions: is the average number of times per year that a customer is affected by an interruption not longer than 3 minutes (transient and short interruption). It is expressed in number of short interruptions/number of consumers/year.

- A)6/a: average number of transient interruptions: $A_K^r = \frac{\sum_{i=1}^{n} f_i^{Kr}}{F}$

- A)6/b: average number of short interruptions: $A_K^{á} = \frac{\sum_{i=1}^{n} f_i^{Ká}}{F}$

f_i^{Kr} : number of customers affected by each transient interruption

$f_i^{Ká}$: number of customers affected by each short interruption

A)7. Number and proportion of customers with the worst supply:

A)7/a. Classification of customers according to the duration of unplanned long interruptions affecting them. It is expressed in the number of customers supplied within a determined timeframe/number of consumers affected/year.

- the number and proportion of customers affected by an unplanned long interruption with a duration shorter than 0,5 hour:

$$A_K^{h-0,5} = \sum_{i=1}^{n} f_i^{Kh-0,5}$$

$$A_{K\%}^{h-0,5} = \frac{\sum_{i=1}^{n} f_i^{Kh-0,5}}{\sum_{i=1}^{n} f_i^{Kh}} \times 100$$

$f_i^{Kh-0,5}$: number of customers affected by an unplanned interruption shorter than 0,5 hour

f_i^{Kh} : number of customers affected by each unplanned interruption

- the number and proportion of customers affected by an unplanned long interruption with a duration between 0,5 hour and 3 hours: its calculation is similar as described above

- the number and proportion of customers affected by an unplanned long interruption with a duration between 3 hours and 10 hours: its calculation is similar as described above

- the number and proportion of customers affected by an unplanned long interruption with a duration longer than 10 hours: its calculation is similar as described above

A)7/b. Classification of customers according to the number of unplanned long interruptions affecting them. It is expressed in the number of customers affected by a determined number of interruptions/ number of consumers affected/year.

- the number and proportion of customers affected by less than 3 unplanned long interruptions per year:

$$A_K^{h0-3} = \sum_{i=1}^{n} f_{ik}^{Kh0-3}$$

$$A_{Kt\%}^{h0-3} = \frac{\sum_{ik=1}^{n} f_{ik}^{Kh0-3}}{\sum_{i=1}^{n} f_i^{Kh}} \times 100$$

f_{ik}^{Kh0-3} : number of customers, who experiences less than 3 unplanned long interruptions per year and are affected by the event

- the number and proportion of customers affected by more than 3 but less than 6 unplanned long interruptions per year: its calculation is similar as described above
- the number and proportion of customers affected by more than 6 but less than 10 unplanned long interruptions per year: its calculation is similar as described above
- the number and proportion of customers affected by more than 10 unplanned long interruptions per year: its calculation is similar as described above

A)7/c. Classification of customers according to the number of unplanned short interruptions affecting them. It is expressed in the number of customers affected by a determined number of interruptions/ number of consumers affected/year.

- the number and proportion of customers affected by less than 10 unplanned short interruptions per year:

$$A_K^{r-10} = \sum_{ik=1}^{n} f_{ik}^{r-10}$$

$$A_{Kt\%}^{h0-3} = \frac{\sum_{ik=1}^{n} f_{ik}^{r-10}}{\sum_{i=1}^{n} f_i^{Kr}} \times 100$$

f_{ik}^{r-10} : number of customers, who experiences less than 10 unplanned short interruptions per year and are affected by the event

- the number and proportion of customers affected by more than 10 but less than 30 unplanned short interruptions per year: its calculation is similar as described above
- the number and proportion of customers affected by more than 30 but less than 70 unplanned short interruptions per year: its calculation is similar as described above
- the number and proportion of customers affected by more than 70 unplanned short interruptions per year: its calculation is similar as described above

B) For the security of electricity supply the following indicators are determined in the regulatory resolution:

B)1. Outage rate: is the ratio of the amount of energy not supplied due to unplanned long interruptions to the amount of available energy. It is expressed in MWh/GWh – ‰.

B)2. Number of medium-voltage unplanned long interruptions in the medium voltage networks per 100 km: It is expressed in the number of interruptions/100 km and calculated separately for the overhead line and cable line medium voltage circuits.

B)3. Average restoration time in case of medium voltage interruptions: is the ratio of the total restoration time of all unplanned long interruptions to the total number of unplanned long interruptions. It is expressed in the duration (min.) of restorations/number of interruptions/year and calculated separately for the overhead line and cable line medium voltage circuits.

B)4. Average unavailability of the 120 kV lines:

$$TRN‰ = \frac{\sum_{i=1}^{n} ua_i^{Kh} \times 1000}{N_{120kV} \times 8760}$$

ua_i^{Kh} : duration of unavailability of a 120 kV line

N_{120kV} : number of 120 kV lines

Regarding the number of short interruptions the Hungarian norm MSZ EN 50160:2008 only defines indicative levels as follows: *"Under normal operating conditions the number of short interruptions is between a few tens and several hundred per year. The duration of the 70 % of the short interruptions can be less than 1 second."* [11] After had been involved in the preparation of 3rd CEER Benchmarking Report on Quality of Electricity Supply (December 2005) the Hungarian regulator decided to overcome the problem of having only indicative levels instead of maximum values by determining the number of short and transient interruptions in 70 per year and in 40 per quarter year. In case these requirements are not met compensation is paid to the customer. The number of short and transient interruptions is calculated from SCADA information, and where it is not available, the counter readings on reclosing devices (these are circuit breakers, which automatically restore power supply after a momentary fault) is used.

3.1.1. The incentive regulation system

The regulatory resolution defines minimum quality requirements for three indicators, which means that non-compliance with the required quality level linked to these indicators implies economic consequences for the company (hereinafter referred to as quality indicators with incentives). These indicators are:

- A)1/h. Average number of long unplanned interruptions
- A)2/h. Average duration of long unplanned interruptions
- B)1. Outage rate

To some other quality indicators of the regulatory resolution only expected quality levels are linked, therefore the non-fulfilment of these quality levels do not involve any direct consequences (hereinafter referred to as quality indicators without incentives). These indicators are:

- A)1/t. Average number of long planned interruptions
- A)2/t. Average duration of long planned interruptions

- A)4/a. The proportion of customers supplied within 3 hours in case of an unplanned interruption
- A)5/a. The proportion of customers supplied within 6 hours in case of a planned interruption
- B)2. Number of voltage unplanned long interruptions per 100 km in the medium voltage networks
- B)3. Average restoration time in case of medium voltage interruptions

Those quality indicators which were presented in the previous section but are not listed in the above two categories are the so-called monitoring type of indicators, for which the actual performances shall be reported by the DSOs but neither required levels nor sanctions are linked to them. They may serve as an input for a future regulation.

For the three *quality indicators with incentives* the required quality levels were determined for the three-year average performance of 2004-2006 based on the actual data provided by the six DSOs for the period of 2002-2004. It means that the required performance determined for the three-year average of 2004-2006 is used as a basis when calculating the requirements for the next three-year periods. In addition the licensees are obliged to meet a predefined annual improvement, the degree of which is higher as long as the difference between the actual performance of the company and the predefined threshold (which is the same for all DSOs) is high and decreases as the company's performance is improving.

For example in case of indicator A)2/h. companies with a basic performance (2004-2006) above 120 minutes shall improve their performance annually by 10%, then after having achieved a performance between 90 and 120 minutes, the expected rate of improvement decreases to 5%, and below 90 minutes to 2%. As the data reported for 2002-2004 was different per DSOs due to the different technical and topological features of their networks (different ratio of overhead line and cables, flat of hilly area, low or high population density, etc.), the basic requirement was also set individually and differently for them. Although the degree of required annual improvement is theoretically the same for all of them, the base relative to which the requirement for the next years is calculated taking into account the required yearly improvement is different for each DSO, in practise companies with a better base performance (2004-2006) are expected to provide a lower rate of improvement over years than companies with a much weaker performance. Figure 1 gives an illustration for the result of the above mentioned differences in the technical features: the performance of the distribution companies shows a high variation, especially in the beginning of the 2000s. Some years later impressive improvement was achieved by all DSOs, and therefore the initial high differences in the companies' performances was gradually smoothing. The purple curve represents the rate of overhead lines in the distribution networks. It can be observed that companies with higher cable rate could provide much better performances, accordingly stricter requirements were defined for these companies for the basis of 2004-2006.

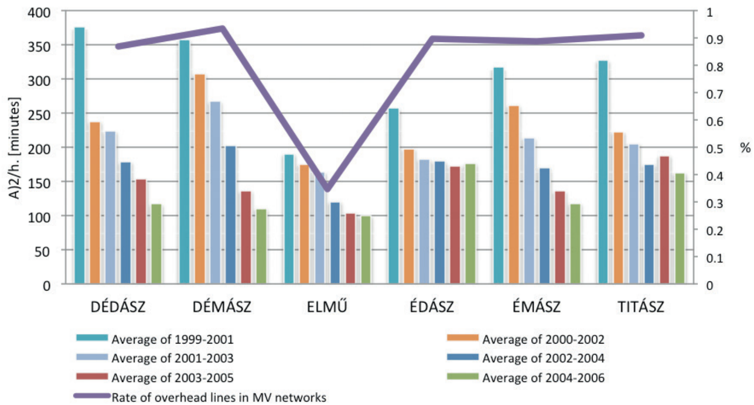

Figure 1 – Illustration of differences in the performances of the DSOs due to the different features of their network with special regard to the rate of overhead lines

The reason for using the three-year average values is to decrease the effects of weather conditions upon the performance of the company and therefore upon its compliance or non-compliance with the requirements, since the quality data reported by the licensees between 1994-2001 showed that their performance was changing year by year reflecting more or less the changing weather. So in practise the average performance of the company in the last three years in relation to the quality indicators defined in the resolution is measured against the requirement which is calculated from the basic requirement determined for the company for 2004-2006 and corrected with the required annual improvement. Thanks to the above presented transparent and clear calculation method the DSOs are aware of the requirements set for them for the actual and also for the upcoming years.

Similarly there are expected annual improvements associated with the six *quality indicators without incentives,* except that no sanctions are applied in case a company is unable to meet the increasingly strict requirements.

The regulator incentivises the DSOs to improve the quality of supply by making the distribution network charges dependent upon the compliance with the requirements defined for the three *quality indicators with incentives.* If a company fails to provide the required standards, its network charges are automatically decreased with the following degree:

- by 1 % for half a year if the deviation from the requirements is between 5 and 10%;
- by 2 % for half a year if the deviation from the requirements is more than 10%.

There is a 5 % dead band, meaning that if the deviation is below 5%, no reduction of the distribution network charges is required.

Annual reports:

The DSOs are required to report the values of the previous year and the average value of the last three years for the indicators presented in Section 3.1. The evaluation of the data reported by the DSOs is carried out by the regulator on annual basis. It includes the assessment of continuity of supply on national level and by licensees, a benchmarking of the licensees' performance, the fulfilment of requirements determined for the three-year average of the current and the last two years and the requirements for the next three-year period (here the next three-year period means the period of the next year, the current year and the last year) are also presented in it. The evaluation is finalized and published after a consultation hold by the regulator with the participation of representatives of the licensees and the consumer organizations, at which the comments of the participants are discussed and the necessary modification are made. If it is necessary according to the results of the assessment, the reduction in the network charges of the relevant company is applied from 1 July.

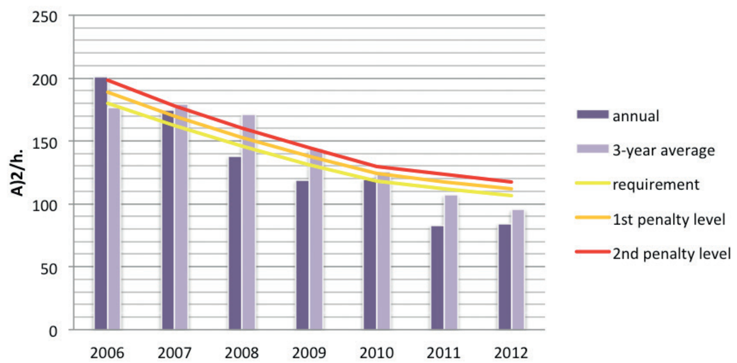

Figure 2 – Illustration of the incentive mechanism and the yearly required improvement

Figure 2 shows the annual and the three-year average performance of a distribution company for A)2/h. indicator between 2006-2012. In the first three years only a slight improvement was achieved by the company in the three-year average values, which was obviously not enough to meet the increasingly strict requirements. In 2006 the deviation from the required quality level was within 5%, therefore no financial consequences were implied. Next year the company could not improve in line with the expectations, consequently the first, and then one year later also the second penalty level was exceeded, which resulted in 1% and 2% reduction in the distribution network charges (cca. 500.000 € and 1.000.000 €). Due to the significant improvement achieved by the company in 2008 and the fact that negative effect of the weak performance of 2006 was not considered anymore, from 2009 the company was able to follow the required level of improvement and in 2011 it has performed beyond the expectations.

3.1.2. Exceptional events

Some interruptions are considered to be due to exceptional events and are either not considered in the statistics or are treated separately. Different countries use different criteria to decide if an interruption should be treated as an exceptional event. Exceptional weather or other circumstances, like vandalism can result in component failure even if the components are designed correctly, using reasonable safety margins, as it is not possible to design a power system that can cope with any situation. Such outages are considered to be outside of the control of the system operator. However there is no harmonised definition of exceptional event in Europe. It is considered exceptional when a large number of network components fail in a short period of time due to external circumstances. In such cases the exceptional weather conditions, like snow storms, high winds, floods can make it very difficult for the repair crews to repair the components, especially when it is almost impossible to access the affected areas, e.g. when the soil is soaked due to heavy rains. Interruptions due to exceptional events can be very long. [4]

In Hungary the definition of exceptional event included in the regulatory resolution covers the followings:

- system breakdown;
- acts of terrorism;
- any event classified by the regulator as "other event" (e.g. strain exceeding the design requirements).

These events shall be included in the annual reports of the DSOs, but can be excluded from the calculation of the quality indicators.

For the procedure of classifying an event as "other event" - including the data to be reported, the deadline for submitting the report, the content of the report - the regulatory resolution do not include any requirements or guidelines, the currently used method described here was gradually developed by the regulator with the contribution of the DSOs over the past few years based on the experiences gained from the previous events.

The procedure has the following steps:

1. When an event considered by the DSO as an exceptional event occurs, the DSO shall immediately give preliminary information to the regulator on the number of interruptions, the number of affected customers, etc. After the event has ended the DSO shall submit a summary report on the incident and a request for approval of classification of the event as "other event".
2. The regulator analyses the reported data taking into account the weather conditions which caused the interruptions, the actions which were taken by the DSO in order to repair the failures and all other circumstances which had an impact on the restoration of supply.
3. If the regulator finds that the classification of the event was appropriate, than the DSO is allowed not to take into account the impact of the event in the actual performance of the quality indicators.

The report on the "other event" shall contain information on the followings (it is not a full list):

1. The full list of interruptions associated with the "other event" including the following information:

a) for interruptions on the medium-voltage network: the affected MV line

b) for low-voltage faults: the affected settlement

c) the reference numbers of the interruptions

d) the start dates and end dates of the interruptions

e) the number of consumers affected by the interruptions (which gives the numerator of A)1/h indicator)

f) the amount of energy not supplied (which gives the numerator of B)1. indicator)

g) the number of affected consumers multiplied by the aggregated duration of the interruption at each consumers – for those consumers who were supplied before the interruption has ended the real duration of the event is considered (which gives the numerator of A)2/h indicator)

h) detailed description of the failure(s): the nature of the failure, the indirect and direct cause of the failure, the failed or damaged network components

2. Examination and analysis of the causes of interruptions (e.g. broken power poles, broken power lines, damaged insulators, network elements, etc.)

3. The cumulated impact (expressed in accurate values) of the interruptions on *quality indicators with incentives* (A)1/h., A)2/h. and B)1.) and also on *quality indicators without incentives* (A)4/a., B)2. and B)3.) separately for MV and LV networks.

4. Analysis of the weather conditions prepared by the Hungarian Meteorological Service (hereinafter: HMS) for the time period in which and for the territory where the massive number of interruptions occurred. Based on the results of measurements performed at the meteorological stations and by using interpolation methods the HMS is able to create maps covering the whole operational area of the DSO or smaller specific areas. These interpolated maps providing calculated values for the relevant period of time are used by the regulator to compare the actual strain magnitude the different network elements with different locations were exposed to with the design requirements. The type of maps is differentiated according to the nature of the weather event, but wind speed and frost depth maps are the most commonly used types in these meteorological studies.

5. Comparison of the actual strain the networks were exposed to during the event and the design requirements: The Hungarian norm MSZ 151-1:2000 – which defines the installation prescriptions for overhead lines – serves as a basis for the examination of the design requirements. The norm determines the level of mechanical load to be taken into account when designing the network, including wind load, frost load, ice load, snow load, etc. However the cumulative effect of these weather elements on the mechanical designing requirements is not considered in the norm. Thus in such cases the DSO has to confirm that the cumulative effect of e.g. the wind and frost has exceeded the design requirements by presenting an expert opinion or a study prepared by an independent body. [12]

6. Any other document, which proves that the DSO has done everything in order to avoid the emerge of interruptions due to the event and to minimise their number and impact, for example the followings:
   a) Documents proving that the number of persons in the repair crews on standby was increased in accordance with the meteorological forecasts;
   b) Description of resources of external contracted parties used for the restoration of supply (the amount of external resources, the parties which provided the resources, the duration of the resourcing, etc.);
   c) Report on the total amount of resources used during the event (staff, equipment, tools, etc.);
   d) Documents proving that the DSO was not able to replace all damaged network elements using its own reserves or it had to purchase new elements;
   e) Report on the number of backup power sources used during the event;
   f) Minutes of the on-site inspections of the power lines affected by the interruptions caused by the event, including ratings of network elements according to their condition, description of the maintenances performed;
   g) Description of the frequency and method of tree trimmings around power lines;

h) Description of any circumstances which hindered the repair crews in the restoration of supply, e.g. the soil was so soaked due to heavy rains, that the DSO's repair crew was unable to access the area using its unconventional vehicles and had to borrow military vehicles to approach the site.

7. Cooperation between the DSO and the County Disaster Management Directorates, information on the number of alarms received and on rescue operations performed by the Directorates.
8. Presenting the way the mayors or notaries of the settlements affected by the event have been informed of the current situation (continuously updated number of affected customers) and of the expected restoration times.
9. List of releases and news concerning the event in newspapers (both printed and electronic) and at online news portals.

The request for approval of classification of the event as "other event" shall be submitted within a month after the event, but if the preparation of some parts of the report requires more time, e.g. the meteorological study, or the study on the mechanical strain the network elements were exposed to during the event, than those parts can be presented later.

Based on the findings of studies made by independent bodies a few years ago, the regulator accepts that wind load over 100 km/h itself means a strain exceeding the design requirements. If there is another type of load besides the wind load, e.g. frost load, than the cumulative impact of these loads is even more significant, and in this case a lower wind speed (60-80 km/h) combined with frost depth of 50-80 mm may result in the damage of the network elements. In these cases it is at the regulator's discretion whether to accept the event due to these weather conditions as an "other event" or not. So as a summary there is no standardised method for the classification of "other" events, therefore the regulator makes a decision on each case individually taking into account all specific circumstances.

Figure 3 shows the impact of "other" events on the actual value of A)2/h. indicator. The dark purple columns represent the average duration of long interruptions per year excluding all events, the light purple ones show the minutes lost per year due to "other" events. In 2008 11,6%, in 2009 21,6% and in 2010 22,72% of long interruptions was caused by "other" events, while in the last two years their effect decreased significantly thanks to the more favourable weather conditions.

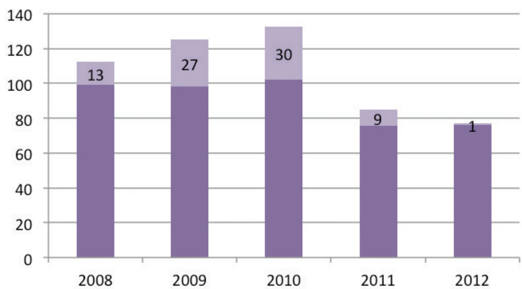

Figure 3 –Unplanned long interruptions due to „other" events and all events excluding the „other" events

Besides the extreme weather conditions there are other circumstances which cannot be controlled by the DSOs, e.g. intentional damage or theft of the network elements. Both the measures taken to prevent such incidents (e.g. hiring security guards or private investigators, installing sensors which provides an alarm signal remotely when an unauthorised operation has been taken on the network) and to eliminate the problem if the damage already has been done (replacement of the equipment and the restoration of supply in case the damage of the network element caused the interruption of the electricity supply) may result in a significant cost for the DSO. As the number of these incidents have been strongly increasing over the past years, their effect on the *quality indicators with incentives* becomes more and more significant. Last year the DSOs initiated a consultation with the regulator with the aim of getting the regulator's approval of not considering these incidents in the quality indicators. At the meeting the DSOs presented their experiences related to these incidents, including the frequency of their occurrence, the most typical methods, the estimated worth of the damages caused and the measures taken in order to prevent such incidents from occurring. The outcome of the consultation was positive from the DSO's point of view, as the regulator allowed them to remove the impact of those cases from the quality indicators, which were reported to the police.

As it was mention in the introduction of this section, there is no harmonised definition of exceptional event in Europe, therefore different methods are applied by European regulators for the classification and handling of these events. The evolution of the Italian exceptional event handling concept was presented in the 4th Benchmarking Report. According to that, in the first regulatory period an event was considered a *force majeure* event when a natural disaster or severe weather condition occurred and only if network design requirements were exceeded. The exceptional nature of the event had to be justified by the DSO with written technical or administrative evidences, e.g. wind speed measurements made by an independent weather centre. The "documentation" procedure turned out to be rather burdensome for both companies, which had to collect continuity data and related written evidence for *force majeure* events, and for AEEG (the Italian regulator) that controlled the documentation provided. In order to simplify the "documentation" procedure, the Italian regulator introduced a statistical method in 2003 to define "major event days". The statistical methodology (called "EPR") that was based on a two-step statistical analysis of the daily values of continuity indicators CAIDI (=SAIDI/SAIFI) and SAIDI. The EPR method considered the days in which these indicators presented both an abnormally high daily value as "major event days". The interruptions occurring during "major event days" were excluded from the calculation of the incentive-based regulation. This method was employed on a voluntary basis in the period 2004-07. Companies were allowed to choose between the EPR statistical method and the application of *force majeure* classification. For the third regulatory period (2008-2011), AEEG developed a new statistical methodology for the identification of exceptional events, which is based upon a statistical exploration of the distribution companies' records of each single electrical service fault. According to this statistical analysis, a simple computational algorithm identifies the exceptionality threshold as a function of the average number of faults in a 6-hour time interval as observed in the last three years. Each 6-hour time interval is considered exceptional (exceptional period, EP) if in the given 6 hours a number of faults higher than exceptionality threshold is observed. The exceptionality thresholds are different for LV and MV faults. For the calculations of these thresholds and for more information on the method please refer to the 4th BR. [4]

Similar to the Italian case, the Hungarian regulator experienced many times the disadvantages of the extensive documentation procedure and also recognized the risks of this quite subjective evaluation of exceptional events. Therefore the regulator is planning to revise the procedure of classifying the exceptional events and as a result it may introduce a much more transparent and verifiable method.

3.1.3. On-site audits

The credibility of the continuity of supply regulation primarily depends on the consistency and accuracy of reported data. The main objective of the audits therefore is to verify whether regulated companies are correctly applying the instructions and guidance for measuring and reporting of data. Furthermore the minimal level of accuracy while performing the monitoring is verified. In case audits are not performed, the quality of data is not verified and the use of such data is therefore questionable. [5]

According to the 4th Benchmarking Report less than half of the surveyed countries carries out regular on-site audits on continuity data; namely Hungary, Italy, Lithuania, the Netherlands, Norway, United Kingdom, Portugal, and Spain. Finland, Romania and Sweden are interested in implementing audit procedures in the near future. On-site audits can be conducted by different authorities: by the regulator (as in Hungary, Italy, Lithuania, the Netherlands and Norway), by consultants on behalf of the regulator (as in the United Kingdom) or by consultants on behalf of the companies (as in Spain and Portugal). [4]

Normally audits are performed by the Hungarian regulator on annual basis. Each of the regulatory resolutions issued in the different field of quality of supply includes an annex, which defines some requirements on the data provision, briefly summarizes the inspection method applied by the regulator and specifies the amount of the penalty the company is imposed on in case the reported data was incorrect. For continuity of electricity supply an order of procedure was issued on the inspection of reliability of data reported by the DSOs. Its objective was on one hand to provide a methodology, which enables the regulator to carry out the inspections in an unambiguous and objective way and on the other hand to give assistance to the licensees when carrying out their own inspection tasks.

The order of procedure covers all the three voltage levels. For the different voltage levels the following events fall under the scope of the audits:

- *low-voltage events:* planned or unplanned failure of the electricity supply, which causes customer interruption and which should be restored by the intervention of the Licensee and registered in the Licensee's information system. These are the following:
- Supply failure affecting a single customer,
- Supply failure affecting more customers.

- *medium-voltage events:* planned and unplanned events which took place on the medium voltage network belonging to the scope of authority of the dispatch centre to be inspected (including also the high voltage devices of transformation stations) and which affect quality of supply. These are the following:
  - Various types of closures,
  - Failures due to the intervention of the operational staff,
  - Network activities planned or allowed by the operator, resulting in the non-supply of customers carried out in an allowed period of time or for a longer period,
  - Events originating from external factors, which affect electricity network and cause a disturbance in supply.

- *high-voltage events:* all events registered at the dispatch service controlling the high voltage network of the licensee and affects 120kV transmission lines and transformers, which influence the normal state of operation and the quality of customers' supply. In addition to this, high voltage events include also those events that do not cause either customers outage or disturbance, but affects the normal state of operation permanently and adversely.

The inspection is based on the rules of simple random sampling without replacement, but does not comply with the prescriptions of the relevant standard. In the application of the method, a repeated sampling shall be made if the first sampling circle contains an element qualified as inappropriate. 5-5 events shall be picked from the unplanned and the planned events in the course of the first sampling. Selection shall be carried out on the basis of calendar parameters (month, day) in order to meet the requirements of uniformity and randomness. A day (possibly the same day than the day of inspection, if not possible than the day following this day) shall be selected in the chosen even or odd months and an event shall be selected for this day with the cooperation of the representative of the licensee. An event may be appropriate or inappropriate from the point of view of data collection and data processing in accordance with section *Qualification*.

Licensees collect and process source data accompanying operational events partly in an automated (telemechanics, supporting softwares) and partly in a manual (logs, tables) way. Several data may belong to a certain event, therefore an event shall be evaluated from the aspect of data collection through the evaluation of the associating basic data. In the course of data processing, information may switch data carriers several times by human intervention. Inspection may be carried out at those points of the process of data collection and data processing where a human intervention took place or the data are easy to access. Inspection shall be performed on the site of the Licensee, where data and data carriers are available. If one of the events of the first sampling circle is evaluated as inappropriate, further five samples shall be examined from that event group.

The regulator may perform two inspections per annum unless provided otherwise by law. The subject of these inspections can be different:

- Qualifying inspection: The date for qualifying inspection shall be the first half of the actual year. The subject of the inspection is the complex inspection of the relevant events of the previous year and the reports submitted on that period. Based on the inspection, the regulator evaluates the report of the licensee, which may be a base for imposing sanctions.
- Corrective inspection: its subjects are the events of the first half of the actual year. In the course of the inspection, a particular attention shall be paid to the elimination of failures revealed as well as to all measures serving for the possible improvement of the system.

Aspects of inspection:

- Complexity of data collection (whether there is any not fully administrated event),
- Accuracy of data collection (equality of data included in the certain documents and consistency),
- Technical reality of data (connected elements, dates, order of dates, etc.),
- Enforcement of internal and external rules and provisions on data collection,
- Accuracy of the number of affected customers (the method is presented in the Annex),
- Proper calculation of non-supplied kWh (the method is presented in the Annex),
- Appropriate evaluation of an event (e.g. planned or non-planned event),
- Inclusion of data in the reporting scheme.

Key steps of inspection:

- Mapping data collection and reporting process or the specification of deviations from the previous version of data collection and reporting process,
- Defining data transfer points (finding places depending on human factors),
- Reviewing the relevant documents, declaring their adequacy and authenticity,
- Reviewing and learning about the internal regulations on data collection and reporting,
- Selecting and identifying events in accordance with the method presented before,
- Tracking the documentation and process of the certain events based on the available documents and technical manuals (maps, computing tables, SCADA system, stress relief instructions, work order form etc.),
- Discussing the events, analyzing the revealed shortages, exploring possibilities for correction,
- Preparing the minutes of the audit.

Documentation of inspection: The minutes shall contain a brief description of events and facts as well as findings. It shall include the qualification specified in the next section based on the inspection aspects specified two sections above.

Qualification: The evaluation and qualification of findings based on the inspection aspects shall be made on qualitative and quantitative basis depending on the nature of a certain aspect. The outcome of a qualification may be 'appropriate' or 'inappropriate'.

Quantitative evaluation: It shall be declared whether the basic and calculated data assigned to the inspected event deviate from the expected (realistic) value by more than 5%. When the rules applied are based on mean calculation and approximation (mostly in the case of estimated data), an event shall be qualified as 'appropriate' if the deviation from the expected value is less than 5%. However, if the deviation is higher than 5%, the event shall be declared as 'inappropriate'.

Qualitative evaluation: In general, the aspects of qualifying inspection may reveal shortages or inadequacy not only with regard to one event. It shall be examined, whether the failure derives from the scheme applied or it is due to human failure. However, inspection shall be continued by a repeated sampling irrespective of the result. [25]

Supply security regulation for natural gas supply

In 2004 a regulatory resolution on the expected quality levels of the security of supply on the natural gas distribution systems was issued by the Hungarian regulator. This resolution defines three quality indicators, by which the companies' performance is measured. These are the followings:

<u>ÜB1. Average duration of interruptions in the gas supply</u>: is the average amount of time per year that a customer is affected by an interruption. It is expressed in the duration (min.) of interruptions/1000 consumers/year.

<u>ÜB2. Average number of interruptions in the gas supply</u>: is the average number of times per year that a customer is affected by an interruption. It is expressed in number of interruptions/1000 consumers/year.

<u>ÜB3. Outage rate</u>: is the ratio of amount of gas not supplied due to interruptions to the amount of available gas.

$$ÜB3‰ = \frac{\sum_{k=1}^{n}(t_k \cdot F_k)}{F \cdot 8760} \cdot 1000$$

t_k : duration of each interruptions

F_k : number of customers affected by each interruptions

F : total number of customers

As it was already mentioned in the introduction, the quality regulation of gas supply security is practically limited to monitoring activity, as even though quality levels are determined for the above indicators, non-compliance with them does not involve any direct consequences. The regulator intends to review the regulatory resolution in the near future, therefore there is no point in presenting the content of this regulation here in more detail.

3.2. Commercial quality

Commercial quality relates to the quality of services provided for customers. It covers the transactions and various forms of contacts established between the electricity and gas companies and the customers. The most frequent commercial quality aspect is the timeliness of services provided for customers.

There are lots of debates on the necessity of regulating commercial quality. The regulator normally does not intervene in the deregulated market, as competition between the retailers is expected to result in sufficient quality, and therefore regulation is not necessary. In those countries, where the competition is well developed in the supply, the market can regulate itself, as the competition is supposed to force companies to perform over a certain minimum level. While in many cases competition does not apply equally to all customer groups like residential customers, who in the lack of regulation may be vulnerable. Some commercial quality aspects relate to the activity of the distribution network operators, for which - due to their monopolistic nature - quality regulation is necessary in order to ensure a sufficient level of quality. [4,5]

Based on the information presented in the Benchmarking Reports it can be concluded that the Hungarian commercial quality regulation is one of the most developed ones in Europe. The services provided for customers by the universal service providers and distribution system operators are regulated both on system level and on individual customer level. The requirements which must be met on individual customer level will be presented in Section 3.5. The system-level regulation is implemented through the regulatory resolution on minimum quality requirements for customer relations. It has a similar structure to the resolution on the security and continuity of electricity supply: the quality indicators are classified into three groups according to the consequences linked to them in case of non-compliance with them. In accordance with the above statements of the 4th and 5th Benchmarking Reports the Hungarian regulator issued a regulatory resolution on the commercial quality aspects of the distribution activity of the DSOs and a separate one for the licensees providing universal service (hereinafter referred as USPs) for customers. In the followings the requirements of these resolutions will be presented jointly but with an indication of the type of the company they are applied to.

The first group of quality indicators are linked to direct incentives, meaning that the non-fulfilment of the required quality levels involves penalty. The indicators and the required quality levels linked to them are presented in the followings:

- Response time to customer complaints and enquiries: 90% of customer enquiries received by the licensee (DSO or USP) shall be answered within 12 days and for 100% of them the answer shall be sent within 15 days.

- Call centre's service level – proportion of customer's calls concerning outages or failures answered by the DSO's staff within the determined timeframe: 75% of these calls shall be answered by the operator within 30 seconds.
- Call centre's service level – proportion of customer's calls reporting the monthly meter readings recorded by the DSO within the determined timeframe: 85% of meter readings reported by phone shall be recorded within 30 seconds.
- Call centre's service level – proportion of customer's calls answered by the USP's staff within the determined timeframe: 80% of customer's calls shall be answered by the operator within 30 seconds.
- Number of customer complaints concerning the activity of the licensee (DSO or USP) received by the regulator and the Hungarian Authority for Consumer Protection (hereinafter: HACP), which proved to be justified per 1000 consumers: this rate shall not exceed 0.040 (it is monitored by the regulator and the HACP)
- Proportion of consumers with waiting time less than 20 minutes at the Customer centres: 90% of customers visiting the client centres shall wait less than 20 minutes before being helped by the licensee's (DSO or USP) staff.

For the second group of quality indicators only expected quality levels are defined, therefore the non-fulfilment of these levels do not involve any financial consequences. These are:

- Response time to customer enquiries for connection to the network if on-site visit is not necessary: 90% of these customer enquiries shall be answered by the DSO within 7 days and for 100% of them the answer shall be sent within 8 days.
- Response time to customer enquiries for connection to the network if on-site visit is necessary: 90% of these customer enquiries shall be answered by the DSO within 25 days and 100% of them the answer shall be sent within 30 days.
- Time for the connection of a new customer to the network: after the customer has fulfilled the technical and economic conditions of the connection, the connection shall be performed by the DSO within 7 days for 90% of cases and within 8 days for 100% of cases.
- Number of customer complaints received by the licensee (DSO or USP) concerning its activity which proved to be justified per 1000 consumers: this rate shall not exceed 0,040.
- Average waiting time at Client centres (of the DSO or USP): it shall not exceed 10 minutes
- Activities to be carried out by the Client centres of the DSO:

– acceptance of customer's claim for network connection
– breach of contract
– consumer service activity
– quality of supply

- Activities to be carried out by the Client centres of the USP:

– reception of customer complaints concerning billing and accounting

- Activities to be carried out by the Client centres of both the DSO and the USP:

– conclusion/modification/termination of a contract
– other customer inquiry
– reception of customer complaints

– information on the general procedures
– information on prices
– information on energy efficiency
– information on consumer protection rules
– cash payment
– credit card payment
– remittance
– application of electronic queue management system
– possibility to preliminary schedule appointments.

The third group of quality indicators involves 6 monitoring-type indicators, for which neither minimum requirements nor expected levels are determined. The primary objective of using these kind of indicators is to learn about the actual quality levels of certain services provided by the licensees, based on which the requirements can be properly determined later, if the regulator finds it necessary. These indicators concerns the number of customer claims, some features of the client centres (e.g. opening hours), the number of yearly meter reading performed by the DSOs and some quality parameters of the billing procedure of the universal suppliers.

There are no significant differences in the commercial quality regulation of the electricity and the gas sector, the above presented quality indicators are applied for gas supply as well.

The incentive regulation system:

In Hungary two – commercial quality related - penalty levels are determined in the regulatory resolution depending on the deviation from the required quality levels. If the difference between the requirement and the actual performance of the company is lower than 5% , the company is not penalized. If the deviation from the requirement is between 5-10%, than maximum amount of the penalty which may be imposed is 167.000 € per quality indicators. The amount of penalty doubles at the second penalty level, which takes effect if the company fails to provide the 90% of the required quality level.

3.3. Voltage quality

In Europe, the most important norm regarding voltage characteristics of electricity supplied by public distribution networks is the CENELEC norm EN 50160. This norm defines, describes and specifies the main characteristics of the voltage at a network user's supply terminals in networks with voltage levels below 35 kV. In most European countries this norm serves as a basis for voltage quality regulation of the distribution networks. Over the years, a growing number of regulators have introduced voltage quality limits that are different from those indicated in EN 50160. [4] Each of these national requirements is stricter than those set by the norm. As an example, for supply voltage variations, most countries use a 10-minute integration period to calculate the r.m.s. voltage [7]. While in Hungary and Norway a one-minute period is used. Some countries use 95% limits, as in EN 50160, but a smaller permissible range of voltage variations, for example Hungary and Spain. Other countries allow a 10% deviation from the nominal voltage, as in EN 50160, but during 99.9 or 100% of the time, for example, The Netherlands (99.9% for HV) and Sweden (100%). Some countries apply two-stage limits, either a larger range for 1 minute than for 10 minute r.m.s. values (Hungary) or a larger range for 100% than for 95% of time (The Netherlands). For more details on the national deviations please refer to the 5th Benchmarking Report [5].

After many years of cooperation between the CEER and CENELEC, a new version of the EN 50160 standard was published in 2010, which includes some improvements compared to the earlier edition. However CEER believes that further improvements are necessary, otherwise the national deviations will increase further and the norm EN 50160 will miss its objective to harmonize the voltage quality standards and performances across the European electricity networks [5,7].

The Hungarian limits for supply voltage variation are shown in Table 1.

Period	Time	Limit	Voltage level
10 min	95%	±7,5% of Un	LV
10 min	100%	±10% of Un	LV
1 min	100%	+15% / -20% of Un	LV
10 min	100%	±10% of Un	MV

Table 1 – Limits for supply voltage variations

The above required levels of supply voltage variations are laid down in form of a Guaranteed Standard in the Hungarian regulation, which means that these requirements must be fulfilled in case of each individual low-voltage customers. The voltage quality verification in case of a customer complaint and the compensation in case of non-compliance with the requirements are detailed in the next section.

3.3.1. Individual voltage quality verification

According to the Hungarian regulatory resolution, which defines the minimum quality requirements of the licensed activity of the distribution system operators concerning individual customers (hereinafter: Guaranteed Standards), if a customer contacts the DSO with a voltage problem, the DSO shall perform a one-week long voltage quality measurement at the connection point of the customer, in order to verify the compliance with the Hungarian norm MSZ EN 50160:2008 and the requirements determined in the Guaranteed Standards (See section 3.5). The DSO shall contact the customer within 10 working days in order to agree in an appointment for the installation of the measuring unit. The measurement shall be started within 5 working days and the customer shall be informed of its results 15 days after the measurement was finished. In case the measurement confirms the nun-fulfilment of any of the requirements described in Table 1, compensation is paid to the customer until the DSO solves the voltage problem. The frequency of compensation increases over time, thus incentivising the DSO to take the necessary measures as soon as possible. The first compensation is due within 30 days after the one-week measurement is finished, one year later the second and the third compensations are paid quarterly, and after one and a half year monthly compensation is due. From the customers' point of view the most appropriate point of the network for measurement is the customer's connection point, as it is the network point for which the DSO has a contractual obligation to provide an adequate supply quality level, and more importantly it ensures that the measured voltage quality represents the quality experienced by the customer. If more customer claims arise from the same LV line, than it is recommended to perform measurements at more point of the particular line in order to ascertain of the nature of the voltage problem and the number of customers affected.

3.3.2. Voltage quality on system level – Voltage quality monitoring

Serving customers with high-quality electricity requires adequate voltage quality of the network/system. The special voltage parameters, which characterize the voltage quality of the network can be determined precisely by comprehensive permanent measurements.

The 3rd Benchmarking Report of the CEER, which was published in 2005 gives the recommendation to regulators to perform continuous voltage quality monitoring and to publish the most critical voltage quality parameters.

In Hungary voltage quality monitoring was initiated by the regulator in 2003. Between 2003 and 2008 400 voltage quality recorders compliant with the norm EN 61000-4-30 (Class B) were installed at the low-voltage network of each of the DSOs for a 6-month period in a rotation system. The cost of the monitoring system was shared between the regulator and the DSOs as follows: the cost of voltage quality recorders was borne by the regulator and the expenses of installation and removal were paid by the DSOs. The goal of the monitoring was to get knowledge of the average voltage quality of the networks, therefore the monitored network points were chosen randomly. After the half-year measurements were finished by the DSOs, the regulator intended to proceed the monitoring by establishing a uniform voltage quality monitoring system, which aimed at facilitating the comparison of the DSOs.

Using the experience gained during the first period of monitoring and taking into consideration the practices of other European countries - including the experience of the Norwegian regulator, which was shared with the Hungarian regulator at a workshop held in Budapest in 2007 - the regulator prepared a recommendation on the voltage quality monitoring system, which provides guidance on the minimum number of measuring devices, the duration of monitoring, the voltage quality parameters to be monitored, the technical requirements of the measuring devices, etc. Taking into account the provisions of the norm EN 61000-4-30 some technical requirements were defined for the measurements in the regulatory recommendation, from which only the most important ones are presented:

a) the accuracy of the r.m.s. voltage measurement shall be $\leq 1\%$,

b) the sampling frequency shall be minimum 800 Hz,

c) the sampling and the measurement shall be performed on a continuous basis,

d) on low-voltage networks line voltage shall be measured, while on medium-voltage networks phase voltages with respect to the ground (and not to a composed neutral) shall be measured,

e) the device shall have an internal clock in order to able to store the time and the length of the events at least with an accuracy of seconds,

f) the device shall register outages (when the supply voltage of any of the three phases is decreases below 10% of the nominal value (Un) defined in Hungarian norm MSZ 1), and both the time and length of the outage shall be stored,

g) voltage dips and swells shall be recorded (when up to a time of max. 40 ms the effective value of supply voltage decreases below 90% of Un, respectively it increases over 110 % of Un,

h) when registering voltage dips and swells a hysteresis of 2 % shall be applied for determining the end of the event, and the time, the rate and the length of voltage dips and swells shall be stored,

i) when calculating THD, the harmonic components shall be taken into consideration up to the 7th number and the base of comparison shall be the current fundamental harmonic,

j) the measurement of THD and the voltage unbalance shall be performed by a sampling of at least 10 minutes.

The representatives of the distribution companies and the consumer organisations were involved in the preparation process of the recommendation, which was finalized after several consultations with the stakeholders.

In the determination of the minimally necessary number of monitoring devices the regulator has also considered economic reasons: the objective was to create balance between covering the greatest possible part of the network and applying the fewest possible measuring devices. The regulator also wanted to avoid redundant measuring results and storage of superfluous information. The number of measuring devices and the optimal place of their installation greatly depend on the target of the measurement and the structure of the network. Besides the monitoring system should be optimized in a way that the recorded quality parameters can be classified using the least amount of data. Considering these principles the minimum number of devices used for voltage quality monitoring on the low-voltage and medium-voltage networks were determined as follows:

- on the low-voltage networks: 1% of the number of low-voltage lines
- on the medium-voltage networks: the sum of number of MV/MV substations and 1% of MV customers
- HV/MV substations: number of HV/MV substations (on the MV busbars).

According to the recommendation the monitoring devices shall be located at those network points of the low-voltage networks, which give an appropriate picture of the voltage quality experienced by the customers of the particular LV line, thus the end points of the low-voltage lines (except the case of increase of voltage) and in case of loop-type networks the middle of the line are preferred. In the medium voltage networks the measurement should be performed in all MV/MV substations and at the connection points of 1% of MV customers. In the HV/MV substations the monitoring devices shall be placed on one of the MV busbars of HV/MV substations.

According to chapter 3.2 and 3.3 of *The GGP on the Implementation and Use of Voltage Quality Monitoring Systems for Regulatory Purposes* (hereinafter: GGP on VQ monitoring) medium voltage side of transformers in all MV/HV substation should be permanently monitored, and measuring units should be placed at a selection of MV customers, possibly at their connection point and on the LV side of MV/LV substations. Regarding the low-voltage networks, voltage quality monitoring should be performed at the connection points of a selection of LV customers and the measurement shall be permanent or last at least for one week.

In Hungary the selection of network points for voltage quality monitoring was done according to different approaches on the LV and MV networks. The DSOs have chosen the practise of locating the portable measuring units at low-voltage network points with suspected voltage quality problems, especially at locations with large supply voltage variations. Thus the results of the monitoring serve as an input for their network development plans. Although this measurement concept does not provide any information on the average voltage quality of the network, it may be beneficial for the customers, as it efficiently contributes to the identification of the "weak" points of the grid, and by performing the necessary actions, this method is expected to result in the improvement of the quality of electricity supply. The results of the monitoring may also help the DSOs to solve voltage problems even before any customer complaint occurs. On the medium-voltage networks the purpose of monitoring is to provide a picture of voltage quality in general.

In accordance with the norm EN 61000-4-30 the duration of voltage quality measurement on the low voltage networks is defined in time period between one week and one month (the experiences from the first monitoring period showed that data measured in the first month covers in 95% the general voltage quality characteristics of the measurement of a six month measuring period). Consequently portable devices can be used to monitor the network points of the low voltage networks, and after the measurement is completed at one location the device is moved to another. With this method a lot of points of the low voltage networks can be measured within a year, but at the same time the relocation of the units takes time and increases the operational cost of the DSOs. In contrast, according to the regulator's recommendation and in line with the recommendations of the GGP on VQ monitoring, the medium voltage networks are permanently monitored.

The regulator has selected the following data and voltage quality parameters for monitoring, which are reported by the DSOs annually:

- Number of measuring devices and total duration of measurements,
- Concept of locating the measuring devices, duration of measurement per locations,
- Distribution of the measuring devices by voltage levels: LV, MV,
- Duration of exceeding the ± 10% tolerance range based on the 10 minute mean voltage values in 100% of the measurements,
- Number of measuring sites supplied with non-standard voltage on a permanent basis,
- Duration of exceeding the limits of the THD (total harmonic distortion),
- Duration of exceeding the limits of the voltage unbalance (if measured),
- Number of voltage dips and swells, classified in a determined table.

This data provision and the evaluation of the data enable the regulator to follow up the monitoring activity of the licensees, including the annual improvement in the number of applied measuring devices and in the number of monitored locations.

Based on the data reported by the DSOs for the year 2012, the voltage quality monitoring system included 1489 monitoring devices covering 10420 low-voltage network points with an average monitoring duration of 8.95 days. In the medium-voltage networks 267 fixed measuring units were installed, their average measuring duration was 10.88 months. According to the results, in 0.27% of the measurement duration the voltage was outside the range of Un± 10% in the LV networks, while at MV level this value was much lower, only 0.011%.

3.4. Customers' satisfaction survey

A regulator cannot provide efficient protection for the energy consumers without having information on their expectations, priorities and satisfaction with energy supply. In order to learn about the opinion of customers regulators usually introduce an information collection method. According to some international regulatory practise these channels of information collection are used even to know what are important for customers, what they are sensible for, in which questions they need the protection of the authority regulating the monopolies. In addition to this regulatory practice the Hungarian regulator has also learned the method applied by some American power utilities, by which they can get information on the opinion of their consumers about their activity. Based on all these background information, an expert committee has been set up to work out a proposal for the method of adapting the international experiences to the Hungarian circumstances. The regulator's goal was to get the assessment of the quality of supply not only from the report of suppliers but also from the consumers' point of view. This subjective, individual judgement of consumers – in case of sufficiently numerous representative samples - can be properly used for the assessment of consumers' satisfaction in comparison among the regions and as a function of time. The experts group has worked out a scientifically grounded method to learn and evaluate the opinion of consumers. Based on the work of this committee, the regulator issued a resolution in 1996 on the method, execution and evaluation of assessment of consumers' satisfaction. [13]

According to the Hungarian regulatory resolution the licensees shall commission an independent public opinion research company to carry out the survey on annual basis. This survey reflects the consumers' views on the performance of the electricity and gas distribution system operators and universal suppliers. The results of the survey reveal the most critical areas deemed by customers and therefore help the licensees to improve the quality levels of their services in line with customer's expectations. The surveys also show the effects of the measures taken by the licensees for improving quality of services over time. From the regulator's point of view these annual customer surveys give feedback on the appropriateness of the regulation in place and highlight those areas which may require stricter rules.

Once a year "professional" inquirers independent from the suppliers collect the answers of consumers given to the previously fixed questions, and an organisation independent from the inquiring organisations coordinates the assessment and the evaluation on national level. Separate questionnaires were prepared for the residential and non-residential consumers. For electricity 7600 residential and 2600 non-residential customers supplied within the universal service system were involved in the research. For gas 7200 residential and 2400 non-residential customers participated in the survey.

Two aspects of electricity distribution activity are in the focus of the survey: the quality of supply, including the continuity of supply, voltage quality, gas quality, restoration of supply and the contact with customers. For the universal supply billing, the performance of the Client centres and Call centres, complaints handling as well as the communication with the customers are assessed.

According to the results of the last few surveys more or less the same areas of the licensees' activity were found critical by the customers. The continuity of supply, voltage problems and the long restoration time in case of a failure were the least satisfactory parts of the distribution activity from the customers' point of view, however based on the feedback from consumers a slight improvement can be observed in these areas. In 2012 40-44% of the residential respondents experienced at least one short interruption, 31-

34% were affected by a long interruption, and 20-24% by supply voltage variations. These disturbances occurred with a higher frequency at non-residential customers, for example 50% of them experienced at least one short interruption in 2012.

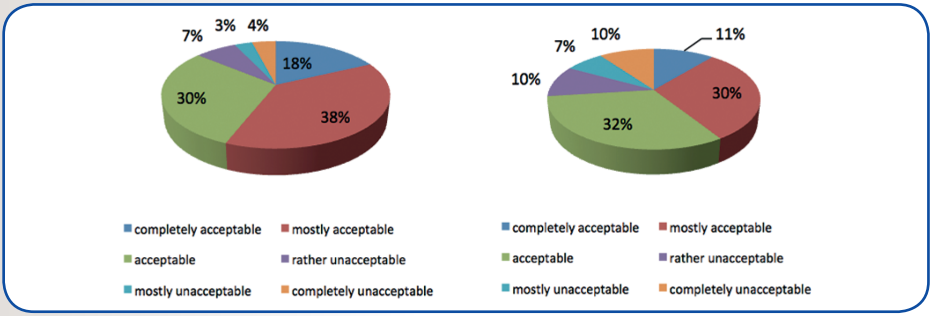

Figure 4 – Frequency of short interruptions - Opinion of residential and non-residential customers

On Figure 4 the attitude of residential and non-residential customers to short interruptions is presented. The result of the survey confirms – which was also suspected – that non-residential customers are more sensitive to not only short interruptions but also to other kind of disturbances of electricity supply.

Regarding the supply activity of the universal suppliers the complaint management is deemed the most critical by both the residential and non-residential customers, at the same time a lot of customers are unsatisfied with the comprehensibility and accuracy of the invoices. The survey shows that electronic form of contact becomes more and more important, at the same time the most popular forms of customer contact are the contact by phone and by personal visit.

The operational efficiency of call centres – which is the mixture of accessibility, fastness, professionalism and efficiency - considered by residential and non-residential customers is presented in Figure 5. It can be concluded that 79% of residential and 77% of non-residential customers are satisfied with the performance of the call centres. The following factors are considered by the respondents as main reasons for the inaccessibility of call centres: menu system was too long, the call was answered by a machine, it was difficult to find the relevant item in the menu system, the line was engaged, nobody answered.

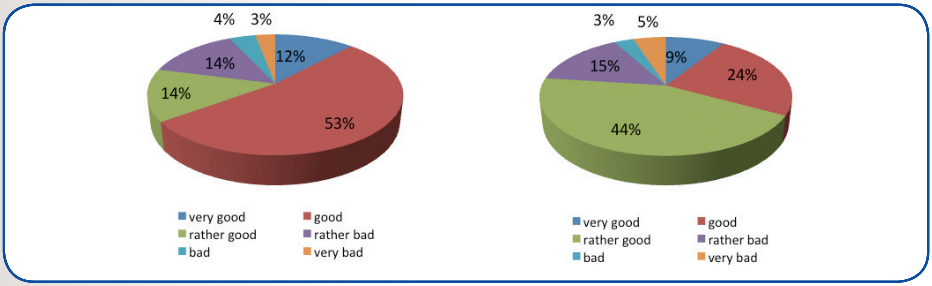

Figure 5 – Operational efficiency of call centres - Opinion of residential and non-residential customers

In the field of gas distribution the quality of supply, technical administration, metering, gas quality are subject of the survey. Continuous and high-quality gas supply is expected by both residential and non-residential customers. According to the results of the last survey customers were satisfied with the continuity of supply and the accuracy of metering. On the other hand information giving on the planned interruption of gas supply has been widely criticized by respondents.

For the universal service the billing, complaint handling, administration at customer centres and call centres and quality of information supply are in the focus of the survey. Similar to electricity the electronic communication form is becoming more and more important; it is almost as popular as the personal way of contact. The performance of call centres has improved, while many of the respondents were displeased with the administration by phone due to the long waiting time.

In the survey the customers' expectations towards as well as their satisfaction with the different elements of the services provided by the universal suppliers and the distribution companies are assessed. The experiences show that there is a "gap" between these two assessments of the same service:

- if the gap is negative - expectation is higher than satisfaction -, that means the company did not perform in line with the customers' expectations;
- if it is positive, than the quality of service provided by the company was beyond the customers' demand.

The analysis shows that the gap is still negative for the majority of the surveyed services, however it is continuously decreasing year by year. According to the results of the survey the size of the gap is also differentiated for the two customer groups: as expected for non-residential customers the difference between the expectation and satisfaction is quite high, while it is lower in the residential customer segment.

In addition to the above the influence of demographic effects on comprehensive satisfaction indicators is also examined in six areas. These areas are: quality of supply, quality of service elements beyond the basic service, invoicing, information provision, customer-friendly behaviour and evaluation of the universal supplier.

The respondents' opinions on the quality of electricity supply are influenced by the age group of the respondents: active workers are more critical than younger or older generations. Clients with a degree are the most dissatisfied. Since a lot of the elderly live in a one-person household, the above fact is reflected by the relatively positive evaluation on the quality of power supply given by one-person households. Both the settlement type and the nature of household correspond with differences in assessment of power supply and supplier. An urban area provides more favourable circumstances for services, so customers living in Budapest and in bigger blocks of flats are relatively satisfied, but clients living in villages or rural houses are also more content than the average. Women in general had also more positive opinions.

Customers above 60 are the most satisfied. People with higher education also seem to be stricter in their opinions. One-person households give the most favourable evaluation on their supplier, the reason of that was explained in the previous paragraph. Higher levels of education go along with a more stern judgement on customer-friendly behaviour. The more urban a settlement is the higher level of education it is characterised by. The higher the education, the better the residence conditions and the more differentiated the thinking of the customer. In urban areas providers can be assessed more critically. [28, 29]

3.5. Guaranteed standards

Guaranteed standards are quality indicators, which provide a minimum level of service that must be met by the electricity and gas companies (including DSOs, USPs and some SPs). These standards have been set to guarantee a level of service that is reasonable to expect companies to deliver in all cases. If the distribution company fails to meet the level of service required, it must make a payment to the affected customer subject to certain exemptions. Payments under the guaranteed standards compensate for the inconvenience caused by inadequate service. They are not designed to compensate customers for subsequent financial loss. The guaranteed standards cover 13 key service areas, including supply restoration, connections, voltage quality and different form of contacts between the customers and the licensees. [14]

As it may will be observed by the reader, some of the Guaranteed standards, which will be presented in this section cover similar services as the quality indicators used in commercial quality regulation (Section 3.2). The difference is that the Guaranteed standards focus on the individual cases and result in a direct compensation to the customers affected in the case of non-compliance with them, while the performance standards of commercial quality show the performance of the licensee in terms of all consumers or a determined percentage of consumers and the licensee is penalized if it has not met the minimum requirements.

In 2003 the Hungarian regulator was authorised by the Act on Electric Energy to define minimum quality requirements for the licensees' activity in regulatory resolutions. Accordingly a regulatory resolution on the minimum quality requirements of the service provided by the licensee for individual customers (hereinafter: regulatory resolution on Guaranteed standards) was issued for each licensee. On 1 July 2008 the final stage of the full market opening was achieved, which allowed household customers to purchase their energy in the free market. In accordance with the relevant changes in the Electricity Act, among others introducing the new market model in which the distribution of electricity and the supplier activity are unbundled, the regulatory resolutions were renewed.

In the winter of 2009 there was a heavy snowstorm in Hungary which resulted in several day long interruption of electricity supply. This event confirmed the need for a revision of the regulation, thus based on international experiences a new part dealing with the exceptional events was included in the regulatory resolution. In the revised resolution both the required restoration times for interruptions caused by extreme weather conditions and the consequences of non-compliance with the requirements were determined. With the extension of the regulation to extreme weather events the regulator aimed at providing a more effective protection of consumers. This new method will be presented in detail later in this Section.

Between 2003 and 2008 compensation due to non-compliance with the requirements was only paid if the customer made a claim in which he/she requested for the compensation, but of course, the DSOs were also allowed to make voluntary and proactive payments to customers, who have not received the required level of service. In this latter case the amount of compensation was lower compared to the ones which were paid on the customers' request. This mechanism provided incentives for the licensees to pay compensation automatically. According to the regulatory resolution the licensees were only obliged to accept those requests, in which the customer mentioned the Guaranteed standards and demanded for the compensation. As the customers were not aware of not only the existence of such standards but of the possibility and the method of getting compensation if those standards are not met, only a very few compensations were paid by the licensees. The regulator aimed at increasing the public awareness of Guaranteed standards, therefore the obligations to send a brief summary of these services attached to the invoice once a year, and to make it available on leaflets and on a poster in the Customer centres were included in the regulatory resolution. Meanwhile the regulator has decided to make the system of Guaranteed standards more efficient from the customers' point of view. In order to give the licensees sufficient time to prepare the necessary actions, the automatic payment system have been gradually introduced by the regulator starting from 2009. Automatic means that the compensation is automatically paid by the licensee in case of non-fulfilment of level of service required without any request of the customer. From 1 January 2011 each of the Guaranteed Standards involves automatic compensation to the affected customers in case the company failed to provide the required quality levels. The introduction of automatism has resulted in a large increase in the number of compensations paid by the licensees as it can be observed in Figure 6. For example in 2009 compensations were paid only in 1.43% of the cases in which the DSO did not comply with the requirements, while in 2012 all compensation were paid automatically, and their number exceeded the number of cases in which the company failed to fulfil the required quality levels with almost 20%. The reason behind this is that in case of GS 9. *Voltage quality on a low-voltage connection point* those customers, who are supplied with non-standard voltage for a long time, e.g. over one and a half-year period get compensations on a monthly basis.

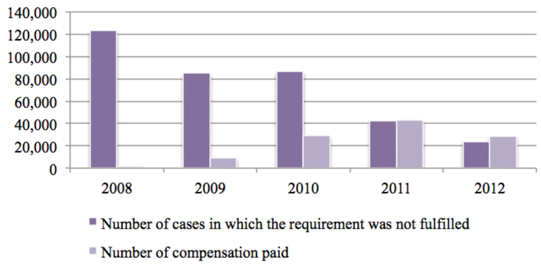

Figure 6 –Increase in the number of compensations paid to customers by the DSOs due to the automatic payment system

Figure 7 shows the progress in the rate of automatic payment for the 13 Guaranteed Standards between 2008 and 2012. In 2008 the automatic payment rate varied between 16.5% and 95.5% for the different GSs with an average value of 49.71%. One year later the average automatic payment rate increased to 86.8%, while in 2012 100% of compensations were paid automatically by the DSOs.

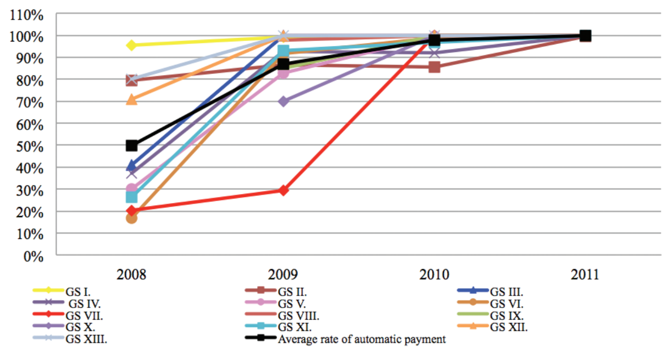

Figure 7 – Increase in the rate of automatic payment from 2008

The amount of compensation was set in 16.67 € for residential customers, in 33.33 € for non-residential customers and in 100 € for customers connected to the medium-voltage network.

Altogether 13 different Guaranteed Standards are defined for the electric distribution system operators, which are presented below. Five of them are also applicable to the universal suppliers and four to the suppliers.

GS I. Time until the start of restoration of supply in case of a single failure: in case of an interruption, which affects only one consumer, the restoration of electricity supply should be started within 4 hours to 12 hours after the consumer's call reporting the failure was received, depending on the population density of the city and on the time and date of the call (if it is a working day or weekend):

- in settlements with a population of more than 50 000 the repair shall be started in 4 hours on weekdays, and in 6 hours on weekends and on holidays,
- in settlements with a population between 5 000 and 50 000 the repair shall be started in 6 hours on weekdays, and in 8 hours on weekends and on holidays,
- in settlements with a population of less than 5 000 the repair shall be started in 8 hours on weekdays, and in 12 hours on weekends and on holidays,
- in the outskirts of the settlement the repair shall be started in 12 hours.

If the consumer's call was received after 8 p.m., then the reparation shall be started next day between 7 and 10 a.m. in the inner city and between 7 and 11 a.m. in the outskirts.

GS II. Time for the restoration of supply in case of failures affecting more than one consumers: the electricity supply shall be restored within 12 hours in case of single and within 18 hours for multiple interruptions after the DSO was notified of it (in case of a failure in the LV network the DSO gets the notification by a consumer's call and in case of medium-voltage failures the notification is automatically sent by the SCADA system). In case of interruptions lasting longer than 24 hours, the amount of compensation doubles and after 36 hours it triples. For interruptions longer than 36 hours the affected customers are paid compensation for every additional 12-hour periods. The time for restoration of supply in case of failures caused by an exceptional weather event is determined according to special rules, which will be detailed later in this section.

GS III. Response time to customer enquiries for connection to the network: customer enquiries for connection to the network shall be answered by the DSO within 8 days if there is no need to visit the customers' premises, and within 30 days for complex works. If a customer contacts the universal supplier (USP) instead of the DSO with a demand for connection, the USP should forward the demand to the proper DSO within two working days.

GS IV. Time for connecting new consumers to the network or extending connection capacity: after the technical and financial conditions of the connection or the capacity extension have been fulfilled by the customer, the connection or the capacity extension shall be performed by the DSO within 8 working days.

GS V. Punctuality of appointments with customers: if there is a work needed to perform at the customer's premises, the DSO and the customer should agree about a 4-hour timeframe, in which the DSO's employee shall appear on the site in order to perform the work.

GS VI. Response time to customer enquiries: all customer enquiries shall be answered within 15 days. If a customer enquiry concerns the activity of the universal supplier or the supplier (SP), the DSO shall forward it to the USP or SP within 8 days.

GS VII. Time for giving information in advance of planned interruptions: customers shall get a notification of all planned interruptions affecting them. The timeframe and the method of the notification depend on the connection capacity of the customer as follows:

- customers with a connection capacity below 200 kVA shall get a notification 15 days before the planned work via a leaflet dropped in the mailbox and via a public notification,
- customers with or above a connection capacity of 200 kVA shall be informed 30 days in advance in a personal letter.

GS VIII. Time for answering the voltage complaint: if a consumer contacts the DSO with the suspicion that there might be a problem with the voltage quality of electricity supply, then the DSO shall contact the consumer within 10 working days in order to agree upon the starting date of the measurement and shall start the measurement within 5 working days. After the measurement has been completed, the DSO informs the customer on the results of it.

GS IX. Voltage quality on a low-voltage connection point: under normal operating conditions at least 95% of the 10-minute mean r.m.s. values of supply voltage shall be within a range of the nominal voltage ± 7.5% during the one-week measurement performed at the customer's connection point. Each 10-minute average values of the one-week measurement shall be within the range of the nominal value±10%, each 1-minute mean r.m.s. values of supply voltage shall be within Un +15 /-20%.

GS X. Redemption in case of incorrect voicing: the licensee (DSO, USP or SP) shall reimburse the overpayment within 8 days after the customers' complaint proved to be justified.

GS XI. Time for meter inspection in case of meter failure: if a consumer contacts the DSO with the suspicion that the electricity meter does not work correctly, then the DSO shall check the meter on the site and if finds any problem, than the meter shall be replaced within 8 days.

GS XII. Time for restoration of supply following a disconnection due to non-payment: the customer shall be reconnected within 24 hours after having justified the payment of the debt and the fee of the reconnection. This standard is also applied for the USPs and SPs, as if a customer informs the USP or the SP about the payment of the debts and fees, the USP or the SP shall notify the DSO within 24 hours about the fulfilment of the conditions of the reconnection.

GS XIII. Unlawful disconnection: if the consumer was unlawfully disconnected from the electricity supply the licensee (responsible for the mistake) shall pay compensation to him or her.

Most of the above standards are also applied with the same requirements, and some with slight differences in the requirements for *gas supply*. Some examples of the differences are:

- customer enquiries for connection to the gas network shall be answered within 30 days;
- customers shall be notified 15 days in advance of a planned work;
- if the gas supply has been suspended due to any other reason than non-payment (e.g. safety reasons), then the supply shall be started within 2 working days after the reason of the suspension was eliminated;
- GS I. and II. are irrelevant, GS VIII. and IX. are obviously not applicable in the gas sector.

Two additional guaranteed standards are defined for gas distribution as follows:

Time for revising the design of the connection pipeline and the consumer device: for new connections and for those connections where transformation of the connection line or the consumer device is necessary, a construction design shall be prepared by the customer, which shall be revised by the DSO from technical and safety aspects the within 15 working days.

Time for carrying out the technical-safety control of the connection pipeline and the consumer device: after the construction is finished, the DSO shall check the existence of technical and safety requirements within 15 days and cannot perform the connection if the requirements are not met.

Table 2 shows the comparison of the required quality levels determined for the GSs applied in Hungary and the European average requirements:

Guaranteed standards used in Hungary	Minimum requirement	European average requirement [6]
GS I. Time until the start of restoration of supply in case of a single failure	4 hours in cities, 12 hours in outskirts	7.16 hours
GS II. Time for the restoration of supply in case of failures affecting more than one consumers	12 hours (for single interruptions) 18 hours (for multiple interruptions)	12.09 hours
GS III. Response time to customer enquiries for connection to the network	8 days (for simple works) 30 days (for complex works)	14.53 days
GS IV. Time for connecting new consumers to the network or extending connection capacity	8 working days	12.16 days
GS V. Punctuality of appointments with customers	4 hours	2.14 hours
GS VI. Response time to customer enquiries	15 days	15.11 days
GS VII. Time for giving information in advance of planned interruptions	15 days (< 200 kVA) 30 days (≥ 200 kVA)	5.69 days
GS VIII. Time for answering the voltage complaint	10 working days	20.11 days
GS IX. Voltage quality on a low-voltage connection point	±7.5% of Un for 95% of 10-minute mean r.m.s. values; ±10% of Un for 100% of 10-minute mean r.m.s. values; +15% / -20% of Un for 100% of 1-minute mean r.m.s. values;	Portugal, Spain, Norway, The Netherlands and Italy also have stricter requirements for supply voltage variations than EN 50160 norm
GS X. Redemption in case of incorrect voicing	8 days	n.a.
GS XI. Time for meter inspection in case of meter failure	15 days	13.29 days
GS XII. Time for restoration of supply following a disconnection due to non-payment	24 hours	3.71 days
GS XIII. Unlawful disconnection	compensation is paid to the affected consumer	n.a.

Table 2 – Hungarian compared with European requirements for individual consumers

[6] Based on the data provided by European countries in the 5th Benchmarking Report

Most Guaranteed Standards used in Hungary defines much stricter requirements compared to the average European requirements. One example is GS VII. for which the 15-30 day timeframes for notification are quite high compared to the European averages of 1 or 2 days. The Hungarian regulator aimed at giving the customers enough time to be able to prepare for these kinds of events in order to minimize the inconvenience these planned works can cause. Another example is GS XII., which ensures reconnection within 24 hours after the financial conditions of reconnection were fulfilled, while in most European countries the reconnection shall be performed by the DSO in 2-5 days.

Application of guaranteed standards under exceptional weather conditions

After a heavy snowstorm in the western part of Hungary in 2009 the regulator recognized that the problem of handling exceptional events should be addressed not only on system level but also on the individual customer level. Therefore the regulator prepared a guideline on the classification and management of the exceptional weather events. In the 3rd Benchmarking Report CEER recommended that NRAs define a set of rules regarding the events which are outside of the control of the DSOs. In the above guideline the regulator reviewed the practises applied by European countries for identifying and classifying exceptional events and decided to create a regulation on this issue on the basis of the method used in The United Kingdom. After a consultation process with the representatives of the DSOs and the consumer organisations, this new method was included in the regulatory resolution on the minimum quality requirements of the service provided by the licensee for individual customers. According to this renewed resolution the extreme weather conditions are classified into four groups according to the number of medium-voltage interruptions in a 24-hour period and the number of affected customers as presented in Table 3.

Exceptional weather category	Definition	Required restoration time, initial trigger period for compensation
1. category (medium events)	– The number of medium-voltage interruptions in any 24-hour period is higher than 8-times but lower than 13-times the daily average number of faults – and the number of affected customers is less than 35% of the exposed customers.	24 hours
2. category (large events)	– The number of medium-voltage interruptions in any 24-hour period is higher than 13-times the daily average number of faults – and number of affected customers is less than 35% of the exposed customers. – Any weather event, which is classified by the regulator as "other event" (e.g. strain exceeding the design requirements).	48 hours
3. category (very large events)	Any weather events where ≥ 35% but ≤ 60% of exposed customers are affected.	$48\text{ hours} \times \left(\frac{\text{Number of customers affected}}{\text{35\% of exposed customers}}\right)^2$
4. category (extremely large events)	Any weather events by which at least the highest number of customers are affected.	there is no required restoration time

Table 3 – Classification of extreme weather events

If the restoration time exceeds the value determined for the 1., 2. or 3. category, the affected customers are compensated for every addition 12-hour periods.

The determination of the daily average number of faults is based on the data provided by the 6 DSO for the period of 2002-2008. As the data reported was different per DSOs due to different technical features of their networks and due to the territorial and geographical differences of their operational areas, different fault limits were defined for each DSOs within the same weather category. (e.g. in case of a DSO – whose operational territory covers the capital and its surroundings, and consequently the proportion of ground cables in its network is much higher than other DSO's with rural operational territory – a lower number of medium-voltage interruptions may be considered exceptional taking into consideration that cable networks are much less exposed to the effects of extreme weather.)

<u>The definition and the determination of exposed customers</u>:

Exposed customers are those customers, who are supplied by overhead lines and who therefore are exposed to the effects of extreme weather.

$$exposed\ customers = total\ number\ of\ customers \cdot \frac{total\ length\ of\ MV\ overhead\ lines}{total\ length\ of\ MV\ networks}$$

The expression of *the highest number of exposed customers* is used for the 60% of exposed customers.

The licensees have the following obligations in relation with guaranteed standards:

a) a description of the Guaranteed standards shall be attached to the invoice or sent separately in form of a newsletter once a year;

b) a description of GSs shall be made publicly available at the Customer centres;

c) customers for whom the licensee could not provide the quality required in the GSs, shall be informed within 15 days about the non-fulfilment of the requirement, the amount of the compensation the licensee is obliged to pay to him/her;

d) a short report on the exceptional weather event shall be prepared and sent to the regulator within one working day after the exceptional weather event occurred, including the times the interruptions caused by the event started, the expected restoration times, the number of medium-voltage lines affected by the interruptions, typical causes of the interruptions, estimated number of affected customers, etc. An updated report shall be sent by the licensee every day until the exceptional event ends.

e) a detailed report shall be prepared and sent to the regulator within one month after the exceptional weather event has ended, which demonstrates that the DSO has done everything to eliminate the faults on the networks and to restore the electricity supply as soon as possible. This report shall contain at least the followings:

a. the starting time and the duration of the weather event which caused the interruptions,
b. the starting time of the interruptions, their restoration times,
c. number of medium-voltage lines affected by any interruption,
d. the total amount of non-supplied energy,
e. the number of affected customers,
f. the description of causes of the interruptions,
g. the feature of the network faults,
h. number of customers affected by interruptions with duration higher than 18, 24, 36 and 48 hours,

i. the time the restoration was started, the expected restoration times, the number of medium-voltage lines affected by the interruptions, typical causes of the interruptions, estimated number of affected customers.

Depending on the number of affected customers and the number of interruptions occurred within the 24-hour periods during the exceptional event the licensee classifies these periods in the appropriate weather category according to Table 3, and requests the regulator to give its consent to the classification of the 24-hour periods and to the application of the restoration times determined in Table 3, meaning that compensations are due only beyond these extended restoration times.

Weather events considered by the regulator as "other events" - if the licensee's report proves its extreme nature and that it involved a strain exceeding the design requirements of the network - automatically get the classification a 2. category exceptional weather event.

The annual report:

The following data on the previous year shall be reported by the licensees by 31 March:

- number of cases falling under the guaranteed standards,
- number of cases in which the requirements has not been met,
- number of compensations automatically paid in case the requirements has not been met,
- total number of compensations paid,
- total amount of compensations paid,
- a short explanation on the reasons of non-compliance with the requirements and if there was any changes in the company's performance (including both the improvements and deteriorations) compared to the previous years, then on its reasons.

Based on the reported data the regulator prepares an evaluation, in which the actual performance of the companies is analysed compared to the previous year's performance and it also includes a benchmarking of the licensees. The reported data reveals the potential problematic areas - e.g. software upgrades of the licensee's SAP system usually results in non-compliance with the requirement of answering the customer letters within 15 days in a huge amount of cases – as well as the effects of improvements in the processes of the company.

On-site audits:

Normally on-site audits are carried out on annual basis, but in case two inspections per year are performed, than - in accordance with the order of procedure, which was issued on the inspection of reliability of continuity of supply data - the subject of the two audits is different. The aim of the first audit is to check the credibility of data reported by the licensees for the previous year. At the same time the second audit has a preventive nature, as it is carried out prior to the data reporting becomes due, and therefore it aims at discovering the potential problems and incentivizing the licensee to implement the necessary changes or improvements. Similar to the audits performed in field of continuity of supply, a random sampling method is used, by which 5-5 cases are picked randomly for the inspected indicators. The management of a case may be appropriate or inappropriate depending on the compliance with the requirements determined in the annexes of the regulatory resolution on guaranteed standards. The data management of the inspected indicator is classified as appropriate only if the registration and management of each of the five randomly selected cases complied with the requirements. If the sample contains any incorrect data, the sampling shall be repeated by selecting other five cases. In case the second sample also includes any incorrect data, the reliability of data reporting related to the guaranteed standard is classified as inadequate. In the latter case the licensee may be obliged to provide a corrected data report and in addition a penalty may be imposed on the company depending on the degree of the deviation from the requirements.

4. Supply quality regulation of transmission networks

Faults on the transmission system quite rare result in customer interruptions, but if those occur, the number of customers affected can be even higher than in case of distribution system faults. The effective regulation of transmission network is therefore highly important from the customers' point of view.

Reliability of electricity supply can be measured using a wide range of indicators depending on the purpose of the monitoring and the interest of the party, who requires the data provision. Therefore some working groups have been created by international organizations aiming at determining quality indicators for transmission networks. In 1997 a group of experts on quality of transmission services within the UNIPEDE have developed a study, which defines the following indicators for monitoring the availability of transmission networks: [8]

– *Average interruption time (AIT)*

$$AIT = 8760 \cdot 60 \cdot \frac{ENS}{AD} \left[{}^{min}/_{year}\right]$$

ENS: Energy not supplied [MWh/year]

AD: Annual demand [MWh/year]

– *System minutes (SM)*

$$SM = \frac{ENS}{PL} \cdot 60 \left[{}^{min}/_{year}\right]$$

PL: Peak load [MWh]

– *Severity index (SI)*

$$SI = \frac{ENS}{AD} \cdot 10^5$$

UNIPEDE's study has served as a basis for some later reports of EURELECTRIC and CEER. CEER's definition for AIT differs a bit from the UNIPEDE's as follows: [4]

$$AIT = \frac{60 \cdot \sum_i E_i}{P_t}$$

P_t: Average power supplied by the total system [MWh]
E_i: The non-supplied energy for each incident [MWh]

According to the 5th Benchmarking Report transmission networks are monitored in 21 of the 26 responding countries. The most commonly used indicators for measuring continuity of supply in transmission networks are ENS and AIT.

The Hungarian regulator has issued a regulatory resolution on the minimum quality requirements and expected quality levels of the security of supply on the transmission networks in 2003. Similar to the resolution on the security of supply on distribution network this regulation also aims at giving information on the appropriateness of quality of supply the customers are provided with and incentivizing the licensee to maintain a high level of quality.

The regulatory resolution defines numerous indicators for monitoring and reporting concerning the availability of transmission networks, from which only the most important ones – which are included in the evaluation prepared by the regulator – will be presented here:

- ENS: is the amount of energy [MWh] not transmitted to the distribution network or not supplied to customers connected to the transmission network due to an unplanned interruption. For interruptions not longer than one hour the non-supplied energy is calculated by the multiplication of the load (effective power) measured right before the incident occurred and the duration of the interruption. For interruptions with duration over one hour non-supplied energy is calculated by using a reference curve, which is originated of the 1-minute or 15-minute measured load values of a previous day with a similar load.
- *Annual demand* (AD): is the amount of energy transmitted on the transmission network (including the network loss) [GWh]
- *Outage rate:* is the ratio of energy supplied to available energy

$$K = \frac{ENS}{AD}\ [‰]$$

- AIT: UNIPEDE definition and calculation
- *System minutes* (SM): UNIPEDE definition and calculation
- *Peak load:* is the maximum load, which occurred during the year [MWh]
- *Number of interruptions:* is the sum of interruptions causing the unavailability of network elements of the transmission system

$$N_{in}^{HV} = N_{in}^{750} + N_{in}^{400} + N_{in}^{220}\ [pc]$$

- *Severity index* (SI): UNIPEDE definition and calculation
- *Average unavailability of main elements of the transmission network:* is calculated as follows:

$$AUT = \frac{AUTannual \cdot 1000}{N \cdot 8760}[‰]$$

AUT_{annual} : Total duration of non-availability of main network elements [hour]

N : Number of main elements of the transmission network [pc]

- *Selective operation of high-voltage fault protection systems:* is the ratio of selective operations to all operations [%]

– *Annual distribution peak load:* is the value of the highest 15-minute load transmitted to the distribution network or supplied to a customer connected to the transmission network

– *Number of substation equipment faults* (N_{ZA}): is the number of interruptions originated from faults occurred at substation equipments, which caused the unavailability of network elements of the transmission system [pc]

– *Number of substation equipment faults causing customer interruptions* (N_{ZA-F}): is the number of interruptions originated from faults occurred at substation equipments, which resulted in interruptions affecting customers [pc]

– *Average restoration time of substation equipment faults causing customer interruptions:* is calculated as follows:

$$T_{ZA-F} = \sum_{t=1}^{n} \frac{t_t^A}{N_{Za-F}} [hour/pc]$$

t_t^A : restoration time of each interruptions [h]

– Number of faults at the transmission power lines (N_{ZT}): is the number of interruptions originated from faults occurred at transmission power lines, which caused the unavailability of network elements of the transmission system [pc]

– Number of faults at the transmission power lines causing customer interruptions (N_{ZT-F}): is the number of interruptions originated from faults occurred at transmission power lines, which resulted in interruptions affecting customers [pc]

– Average restoration time of faults causing customer interruptions:

$$T_{ZT-F} = \sum_{t=1}^{n} \frac{t_i^T}{N_{ZT-F}} [hour/pc]$$

t_i^T : restoration time of each interruptions [h]

– *Number of interruptions relative to the length of 400 kV networks:*

$$N_T^{400} = \frac{N_{ZT}^{400}}{L^{400}} [{}^{pc}/_{km}]$$

N_{ZT}^{400} : total number of interruptions at the 400 kV networks

L_{400} : total length of 400 kV networks

– *Number of interruptions relative to the length of 220 kV networks:*

$$N_T^{220} = \frac{N_{ZT}^{220}}{L^{220}} [{}^{pc}/_{km}]$$

The incentive regulation system

The regulatory resolution defines minimum quality requirements for two indicators, which are linked with direct financial incentives (hereinafter referred to as quality indicators with incentives). These are:

- *Outage rate*
- *Average unavailability of main elements of the transmission network.*

To other quality indicators of the resolution only expected quality levels are determined without any consequences in case of non-fulfilment of these levels.

Similar to the distribution system operators, the average performance of the last three-year of the transmission system operator is measured against the required values of the above two indicators. If the company fails to provide the required standards a predefined or a calculated penalty is imposed with the following degree depending on the deviation from the requirement:

I. Penalty level: if the deviation is between 5 and 10%, the penalty imposed is equal with the one with higher value out of the followings:

- 167.000 € or
- 2% of the annual turnover (without any taxes) arriving from the transmission system operation activity.

II. Penalty level: if the deviation is higher than 10%, the penalty imposed is equal with the one with higher value out of the followings:

- 333.000 € or
- 5% of annual turnover (without any taxes) arriving from the transmission system operation activity.

Figure 8 and 9 shows the annual and the three-year average performance of the TSO for the two *quality indicators with incentives* between 2007-2012. For the Outage rate a very significant improvement was achieved starting from 2007, and in 2009 there was no failure in the transmission system, which resulted in customer interruption. There was a slight increase in the value of the indicator in 2010, but since than its value has been continuously decreasing. The performance of the indicator *Average unavailability of main elements of the transmission network* shows a continuous improvement, however in 2012 there was a high increase in the value of the indicator, and therefore the company's performance decreased back to the 2008-level. Based on these two graphs it can be concluded, that the TSO has been performed far beyond the expectations.

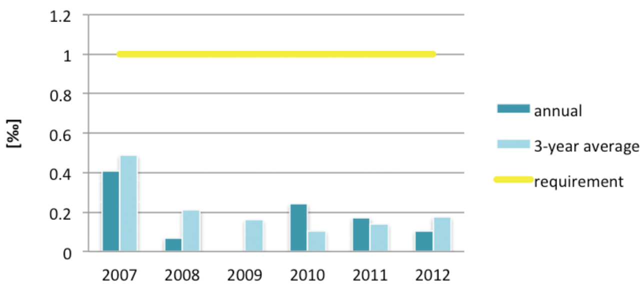

Figure 8 – Outage rate

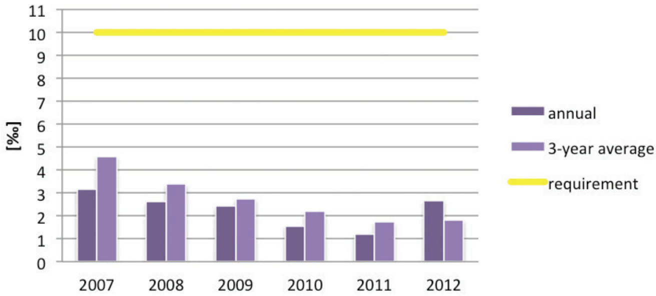

Figure 9 – Average unavailability of main elements of the transmission network

5. Appendix

Determination of network users affected:

The number of affected customers by an interruption cannot be accurately determined by the DSOs without having an up-to-date, precise and adequately detailed consumer database. As most of the continuity indicators are calculated using the number of customers affected by the event, it is especially important to work with real, accurate data, instead of estimated customer numbers. Taking into account how costly and time-consuming the implementation of the necessary developments in the IT systems of the DSOs are, the regulator allowed the DSOs to use estimated data for the calculations until 2012.

In 2011 the regulator has laid down the rules for the determination of the number of consumers affected by interruptions in a regulatory resolution, according to which:

1. in case of a high-voltage or medium-voltage planned or unplanned interruption the number of affected customers is calculated as:

(the number of HV and MV customers connected to the interrupted HV or MV line) + (the number of LV customers connected to the MV/LV transformers affected by interruption).

In order to provide accurate calculation the DSO's database shall include updated data (that allow identification) of all customers connected to the HV and MV lines and of all low-voltage customers supplied by the MV/LV transformers. The database shall be updated with a 30-day frequency.

2. in case of a low-voltage unplanned interruption the number of affected customers is calculated as:

- if all customers have a smart meter, than number of affected customers shall be obtained from data centre of the smart metering system,
- or by the on-site identification of affected customers.
- Otherwise an approximate calculation method can be used, which also requires that the accurate number of customers and the type of their connection (single-phase of three-phase) is directly associated to all circuits. The calculation is the following:
- in case of a three-phase interruption: $AC_{3ph}=C$

- in case of a two-phase interruptions: $AC_{2ph}=C_3+0{,}666*C_1$
- in case of a single-phase interruptions: $AC_{1ph}=C_3+0{,}333*C_1$

where:

AC_{3ph}: number of affected customers by the three-phase interruption

AC_{2ph}: number of affected customers by the two-phase interruption

AC_{1ph}: number of affected customers by the single-phase interruption

C: number of customers connecting to the line affected with the interruption (including three-phase and single-phase connections)

C_3: number of customers with a three-phase connection to the line affected with the interruption

C_1: number of customers with a single-phase connection to the line affected with the interruption

3. in case of a low-voltage planned interruption the number of affected customers is calculated based on the recorded and constantly updated data in DSO's database, or if necessary by the on-site identification of affected customers.

The above calculation methods shall be applied by the DSOs from 1 January 2012.

Calculation of non-supplied energy:

The non-supplied energy is calculated by the multiplication of the load (effective power) measured right before the incident occurred and the duration of the interruption, taking into account the effective load of customers or if it is not available, the capacity of the transformers which were supplied during the incident and the duration they were interrupted.

From 2014 a new calculation method shall be introduced by the DSOs, which is expected to provide a much more accurate calculation of non-supplied energy. It uses reference curves representing the estimated load of the MV line during the time of the interruption if the interruption was not occurred. According to the method first the average load of the MV lines is generated based on the 15-minute measured load values of the lines in the period preceding the incident (including the same days of the 4-week period before the incident):

$$\acute{a}tl_t^n = \frac{terh_t^{n-7} + terh_t^{n-14} + terh_t^{n-21} + terh_t^{n-28}}{4}$$

where:

$\acute{a}tl_t^n$:value of the average load curve at t 15-minute period on n day

$terh_t^{n-x}$: actual load of the MV line at t 15-minute period on n day

In the second step the reference curve is generated with the following method: the values of the average load curve are proportionated to the actual load values of the MV line measured right before the incident, using the ratio of the average of the four 15-minute values measured immediately before the incident to the same period of the average load curve. By the presented method the reference load curve is determined taking into account the significant changes in customers' load within the day and changes of the load due to the changes in the temperature.

6. List of acronyms

DSO: Distribution system operator

USP: Universal supplier

SP: Supplier

CEER: Council of European Energy Regulators

LV: low voltage

MV: medium voltage

BR: Benchmarking Report

GS: Guaranteed standards

EURELECTRIC: The Union of the Electricity Industry

CENELEC: Comité Européen de Normalisation Électrotechnique , www.cenelec.eu

UNIPEDE: International Union of Producers and Distributors of Electrical Energy

AIT: Average interruptions time

SM: System minutes

SI: Severity index

ENS: Energy not supplied

AD: Annual demand

SAIFI: System Average Interruption Frequency Index

SAIDI: System Average Interruption Duration Index

CAIDI: Customer Average Interruption Duration Index

AEEG: Autorità per l'energia elettrica il gas ed il sistema idrico

GGP: Guidelines of Good Practise

SCADA system: Supervisory control and data acquisition system

r.m.s.: root mean square

n.a.: not applicable

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