Council of European Energy Regulators

4TH BENCHMARKING REPORT ON QUALITY OF ELECTRICITY SUPPLY 2008

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PREFACE

From its inception, the Council of European Energy Regulators (CEER) has included quality of supply as one of its main activities. This 4th Benchmarking Report on Quality of Electricity Supply aims to contribute to a better understanding of quality of supply levels and policies in place in Europe, clarifying several aspects which are essential to the electricity sector as well as making information available and contributing to well-balanced rules on quality of supply. To this end, we examine here the three types of electricity quality: the availability of electricity (continuity of supply), its technical properties (voltage quality) and the speed and accuracy with which customer requests are handled (commercial quality).

Liberalisation of electricity markets has brought freedom of choice to consumers, who are able to choose their own electricity supplier. Due to the nature of the infrastructure for electricity networks, transmission and distribution system operators are natural monopolies. A move towards incentive-based regulation for natural monopolies implies important consequences for quality of supply. In order to ensure that quality is not compromised at the expense of company cost reduction measures, regulators include quality factors in their regulatory framework. In this context, the evolution of network regulation has seen the development of regulatory frameworks aiming to strike a balance between cost efficiency and quality of supply. In order to advance the understanding and experience in this area, CEER regulators regularly exchange good practices on how to manage this delicate balance, keeping in mind regulators' core objective to find solutions benefiting society as a whole including taking into account all public and private interests.

The CEER periodically surveys and analyses the quality of electricity supply in its member countries. These surveys and analyses take the form of CEER Benchmarking Reports on Quality of Electricity Supply. The first report was issued in 2001, followed by the second and third editions in 2003 and 2005, respectively. This 4th instalment, along with the previous reports, is freely available at www.energy-regulators.eu.

We hope you will find the information and analysis contained in this report useful and invite you to contact the CEER or your national energy regulator for greater insight into these complex issues.

LORD MOGG
CEER President
Brussels, December 2008

LIST OF ABBREVIATIONS

AEEG	Autorità per l'Energia Elettrica e il Gas (Italian energy regulator)
AID	Average interruption duration
AIF	Average interruption frequency
AIT	Average interruption time
AMM	Automated meter management
ASIDI	Average system interruption duration index
ASIFI	Average system interruption frequency index
CAIDI	Customer average interruption duration index
CAIFI	Customer average interruption frequency index
CEER	The Council of European Energy Regulators
CEI	Comitato Elettrotecnico Italiano
CENELEC (EN)	European Committee for Electrotechnical Standardization: CENELEC issues EN standards
CI	Customer interruptions
CIGRE	International Council on Large Electric Systems
CIRED	International Conference on Electricity Distribution
CML	Customer minutes lost
CoS	Continuity of supply
CQ	Commercial quality
CRE	Commission de Régulation de l'Energie (French energy regulator)
CTAIDI	Customer total average interruption duration index
DGGE	Portuguese governmental offices
DSO	Distribution system operator
DTS	Dispatcher training simulator
EHV	Extra high voltage; refers to voltage levels above 230 kV, ref IEC.
EICTA	European Information, Communications and Consumer Electronics Technology Industry Association
EMC	Electromagnetic compatibility
EMS	Energy management systems
END	Energy not distributed

ENS	Energy not supplied
EP	Exceptional period
ERDF	Electricité réseau distribution France (DSO)
ERGEG	The European Regulators' Group for Electricity and Gas
ERSE	Entidade reguladora dos serviços energeticos (Portuguese energy regulator)
EURELECTRIC	Union of the electricity industry
GS	Guaranteed standard
HV	High voltage; refers to voltage levels above 35 kV up to and including 230 kV, ref IEC. *Note: In chapter 2 on Continuity of Supply; HV refer to all voltage levels above 35 kV, i.e. it also includes EHV levels.*
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IVR	Interactive voice responder
kW	Kilowatt
LV	Low voltage; refers to voltage levels up to and including 1 kV, ref IEC
MAIFI	Momentary average interruption frequency index
MV	Medium voltage; refers to voltage levels above 1 kV up to and including 35 kV, ref IEC
MW	Megawatt
MWh	Megawatt hour
NIEPI	Equivalent number of interruptions related to the installed capacity
NRA	National Regulatory Authority
NVE	Norges Vassdrags - og Energidirektorat (Norwegian energy regulator)
OAR	Other available requirement
OED	Norwegian Ministry of Petroleum and Energy
OS	Overall standard
OSS	Observed sensitive Sectors
PCC	Point of common coupling
PQ	Power quality
QoS	Quality of supply
R&D	Research and development

RMS	Root mean square
RTE	Gestionnaire du réseau de transport d'electricité (French TSO)
RVC	Rapid voltage changes
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SARI	System average restoration index
SCADA	Supervisory control and data acquisition
SI	Short interruptions
SP	Supplier (of electricity, also referred to as service provider)
Ssc	Short circuit power
THD	Total harmonic distortion
TIEPI	Equivalent interruption time related to the installed capacity
T-SAIDI	Transformer SAIDI
T-SAIFI	Transformer SAIFI
TSO	Transmission system operator
U_c	Contractual voltage
UCTE	Union for the coordination of transmission of electricity
U_f	Supply voltage
U_h	a given harmonic component of the voltage, where h is the harmonic order
U_n	Nominal voltage
UNIPEDE	International Union of Producers and Distributors of Electrical Energy
USP	Universal supplier (of electricity, also referred to as universal service provider)
VQ	Voltage quality

COUNTRY ABBREVIATIONS

AT	Austria
BE	Belgium
	- Brussels region
	- Federal
	- Flemish region
	- Walloon region
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
FI	Finland
FR	France
DE	Germany
EL	Greece
HU	Hungary
IS	Iceland
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
ML	Malta
NL	the Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
SK	Slovak Republic
SI	Slovenia
ES	Spain
SE	Sweden
UK	United Kingdom

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1 INTRODUCTION

The Council of European Energy Regulators (CEER) periodically surveys and analyses the quality of electricity supply in its member countries. This 4th Benchmarking Report on Quality of Electricity Supply addresses the three major aspects of electricity quality, namely continuity of supply, voltage quality and commercial quality.

Electricity is expressed in terms of currents and voltages and has several characteristics which define its technical quality, i.e. its availability and usefulness. In a “perfect world”, electricity supply would always be available, voltage magnitude and frequency would be equal to their nominal values and the voltage waveform would be a non-distorted sine wave. Similar ideal properties can be defined for the current, but this report only addresses the supply voltage. In the real world, however, electricity supply is not always available, voltage magnitude and frequency deviate continuously from their ideal value and the voltage waveform is often distorted.

Chapter 2 of the report deals with continuity of supply, which concerns the availability of electricity; one of the three main factors affecting the quality of supply mentioned above. When electricity supply is not available, this is referred to as an “interruption of supply” (or an “interruption”). The fewer the instances of interruptions and the shorter these interruptions are, the better the supply is from the viewpoint of the customer. The design and operation of the power system should be such that the number and duration of interruptions is acceptable to most customers, without incurring unacceptably high costs. Finding a compromise between “reliability” and “costs” has been a subject of discussion for several decades now and will likely continue for years to come. The “optimal supply” can be different for different regions (urban versus rural) for different customers (industrial versus domestic) and will certainly evolve with time as end-user equipment, customer requirements and investment costs change. Chapter 2 contains information about continuity of supply in general as well as monitoring, indicators, analysis of interruption data received from the CEER member countries and information about on-site audits carried out in each country. Chapter 2 also contains information about existing definitions and, where available, regulations in use in various European countries as regards the concept of “Exceptional Events” (c.f. section 2.7).

Chapter 3 concerns voltage quality, which refers to the usefulness of electricity when there are no interruptions. When the voltage quality (the usefulness) is very poor, several problems may arise in the use of electrical appliances and electrical processes; e.g. malfunction, breakdown, trip, damage, reduced efficiency, flickering lights and even explosion and fire. In simple terms, voltage quality can be described by deviations from nominal values for voltage frequency and voltage magnitude and by distortions of the voltage wave shape. These can be further divided into several more parameters or voltage disturbances. Due to the nature of electricity, voltage quality is affected by all the parties connected to the power system. When voltage quality is too poor, a key question is whether the disturbance (e.g. a harmonic disturbance) from a customer’s installation in to the power system is too big or whether the power system (the short circuit power) at the point of connection is too weak. The aim should be to have an electromagnetic environment where electrical equipment and systems function satisfactorily without introducing intolerable electromagnetic disturbances to other equipment. This situation is referred to as electromagnetic compatibility (EMC). Chapter 3 contains information about voltage quality in general, work done by CEER in this area, results from national surveys on costs related to poor voltage quality and information about existing and planned monitoring systems and data.

Chapter 4 focuses on commercial quality, which relates to the nature and quality of customer services provided to electricity consumers. In a liberalised electricity market, the customer concludes either a single contract with the supplier or separate contracts with the supplier and the distribution system operator (DSO), according to national regulation. In both cases, however, commercial quality is an important issue. Commercial quality is directly associated with transactions between electricity companies (either DSOs or suppliers, or both) and customers, and covers not only the supply and sale of electricity, but also various forms of contacts between electricity companies and customers. There are several services that can be requested by customers, such as new connections, starting and terminating supply, meter verification, and so on, and each of them is a transaction that involves some commercial quality aspects. The most frequent commercial quality aspect is timeliness of services requested by customers. Chapter 4 contains information about commercial quality and how it can be regulated, the main results of benchmarking commercial quality standards and the challenges for commercial quality following full electricity market opening.

Overall, this report aims to present an overview and analysis of current practices in CEER member countries, as well as an assessment of areas where a move towards harmonisation could further improve quality of service and consequently electricity markets in Europe as a whole. In this context, it is important to note that quality of supply is an important element of market regulation as a whole and the regulator's role in ensuring the proper functioning of the market, including making information available, protecting worst-served customers and promoting quality improvements. Quality of supply is also closely linked to security of supply. In a climate where investment and market decisions are based on economic priorities, it is important to ensure that the quality of the product, electricity, is not negatively affected by the economic decisions taken by market participants.

Detailed conclusions and recommendations are provided in sections 2.8, 3.10 and 4.5 for the continuity of supply, the voltage quality and the commercial quality chapters, respectively. In addition, the report provides recommendations regarding the need to implement the various tools used to measure and monitor quality of electricity supply, as well as the importance of open and continuous dialogue with stakeholders.

2 CONTINUITY OF SUPPLY

2.1 Introduction

In a “perfect world”, electricity supply would always be available, voltage magnitude and frequency would be equal to their nominal values and the voltage waveform would be a non-distorted sine wave. Similar ideal properties can be defined for the current, but this report only concerns supply voltage.

In the real world, electricity supply is not always available, voltage magnitude and frequency deviate continuously from their ideal value and the voltage waveform is distorted. Continuity of supply concerns the first of these properties of supply. When the electricity supply is not available, this is referred to as an “interruption of supply” or in short “interruption”. The fewer the interruptions and the shorter these interruptions are, the better the quality of supply from the viewpoint of the customer. The design and operation of the power system should be such that the number and duration of interruptions is acceptable to most customers without incurring unacceptably high costs. An acceptable compromise between “reliability” and “costs” has been a subject of discussions for several decades, which will continue for years to come. The “optimal supply” can be different for different regions (urban versus rural) for different customers (industrial versus domestic) and will certainly evolve with time as end-user equipment, customer requirements and investment costs change. It should also be noted that the existing power system is often the result of historical developments and decisions that were made long ago.

Continuity of supply relates to these interruptions and is the subject of this chapter. The aim of this chapter is not to find the “optimal supply”, but to provide information on the existing level of continuity of supply in different European countries, as far as continuity measurements are available and comparable and to provide an overview of the existing practices for monitoring continuity of supply in European countries, including the definitions of indicators to quantify the number and duration of interruptions for individual customers and for groups of customers when measuring the continuity of supply.

The other properties of voltage - magnitude, waveform etc. - fall within the realm of “voltage quality” and will be discussed in Chapter 3 of this report.

2.1.1 Interruptions

An interruption is a situation where the supply is not available for one or more customers. When collecting continuity data and using indicators to measure continuity, it is important to define clearly when supply is considered to be interrupted. There are two, slightly different definitions of an interruption. While the result is, in most cases, the same, they assess interruptions from different sources.

The first definition uses the voltage at the point of connection between the customer and the network. If the voltage magnitude is zero or close to zero, this is referred to as an interruption. The advantage of this definition is that it measures continuity from the customer’s perspective. Monitoring continuity using this definition would require monitoring the voltage of all, or the majority of, customers. Using existing technology, this would require investments beyond what is deemed reasonable.

The second definition of “interruption” uses the galvanic connection between the customer and the network. If there is no galvanic connection between the customer and the main part of the network, this is referred to as an interruption. The start and end of the interruption corresponds to the opening and closing of an interrupting device, like the opening of a circuit breaker or the closing of a load switch. This definition does not directly correspond to customer requirements, but it makes it much easier for the system operator to gather continuity data. In most practical cases, the two definitions are equivalent.

Even when voltage is used in the definition of an interruption, the collection of continuity data is based on the opening and closing of interrupting devices. As the opening takes place automatically with most interruptions and is not always recorded, for the lower voltage levels, it is often the manual closing of interrupting devices that forms the basis for continuity statistics. The start of the interruption is, in many cases, only estimated. For interruptions due to incidents in the low voltage network, some system operators still rely on customers reporting the occurrence of an interruption. For the higher voltage levels, data-acquisition systems like SCADA (supervisory control and data acquisition) or EMS (energy management system) are used to record the beginning and the end of interruptions.

2.1.2 Continuity indicators

Quantifying the continuity of electricity supply requires continuity indicators, typically referred to as “continuity indices” or also “reliability indices”. For benchmarking purposes, and also to be able to reproduce and interpret the statistics, it is important that the indices are defined in a transparent and unique way. This is a non-trivial task as there are still different definitions and methods being used in different countries. In section 2.3, an overview is given of the different continuity indicators that are used in the countries that took part in the survey.

The basis for the calculation of continuity indicators is the collection of information on individual interruptions. An individual interruption is described by its duration and by the size of the interruption. The duration is expressed in minutes or hours; there are different methods in use for quantifying the size. This may be done by counting the number of customers that are interrupted, or by counting the amount of power that is interrupted. Both methods are in use but, as shown in the following paragraphs, the number of customers is the most difficult parameter to quantify for sizing the interruption.

From information on all individual interruptions that took place during the reporting period in the system that is being monitored, a number of system indices are calculated. The majority of indices in use provide a measure for the average number of interruptions that took place or for the average time during which electricity supply was not available.

The disadvantage of system indices is that they only provide information for the average customer, not for any individual customer. An individual customer is, in principle, only interested in the interruptions that impact its point of connection. Suitable indicators for individual customers are the number of interruptions experienced by the individual customers during a given year and the number of minutes that electricity supply was not available for the individual customer.

However, it is not practical to publish indices for each individual customer. This is one of the reasons why, typically, only system averages are published (another important reason is related to the way in which the data is collected). Some indices are available that give more information than just the average number or duration of interruptions of all customers.

An intermediate step, used by some regulators and system operators, is to calculate the continuity indicators for each individual feeder. In that way, a better impression is obtained of the difference in performance between different parts of the system. Some DSOs or regulators are also using indicators on a geographical level for areas with equivalent characteristics, e.g., rural and urban networks.

2.1.3 Planned and unplanned interruptions

Most interruptions are due neither to programmable nor predictable events, but rather to unforeseen events like component failures, lightning strikes, excavation activities, or incorrect switching actions. Those interruptions are referred to as “forced interruptions” or “unplanned interruptions”.

In some cases, an interruption is due to the system operator intentionally opening an interrupting device to de-energise part of the network, including one or more customers. Such measures are typically used to enable maintenance on existing network components or to build new parts of the network. These interruptions are referred to as “planned interruptions” or “scheduled interruptions”.

Planned interruptions are, in most cases, part of efforts to improve the continuity of supply. Therefore, these should be treated separately from unplanned interruptions, which do not serve any purpose for customers.

Another reason for treating planned interruptions separately is that customers can take action to limit the consequences of the interruption if they are notified in advance. Therefore, most regulators set rules about the type of information to be given to customers in advance and the timelines to do so in order for the interruption to be deemed a planned interruption in the continuity of supply statistics. Any interruption not considered to be a planned interruption is counted as an unplanned interruption.

It should be noted that in meshed networks, maintenance does not necessarily result in an interruption. Planned interruptions are, however, unavoidable when repair or maintenance is conducted in parts of the network that are radial, without backup supply paths, unless mobile generators are used or live-line maintenance work is carried out. The earlier-mentioned compromise between reliability and costs results in some parts of the network not having any backup supply paths. Installing such paths for all customers would result in excessive costs.

The difference between planned and unplanned interruptions will be discussed in more detail in section 2.4.6.

2.1.4 Long, short, and transient interruptions

A distinction is often made between the types of interruptions, based on their duration. In most European countries, an interruption is referred to as a “short interruption” if it lasts 3 minutes or less. A long interruption is an interruption that lasts more than 3 minutes. These definitions are in accordance with the European standard EN 50160[1]. Even though this document only applies to distribution voltages up to 35 kV, several of its definitions are applicable to higher voltage levels as well.

The reason for this distinction has to do with the way in which continuity data has traditionally been collected. The event that has traditionally been recorded by the system operator was the manual reconnection of the supply. The start of the interruption, when due to the automatic opening of a piece of

1 EN 50160, *Voltage characteristics of electricity supplied by public distribution networks*, CENELEC, Brussels, 2007. CENELEC standards can be obtained from the national standard setting organisation. It has been decided that a new draft will be sent for vote in the near future; see also section 3.4 in this report.

switchgear (typically a circuit breaker triggered by a protection relay), was not recorded in some cases, or was recorded only by the data-acquisition system and not included in continuity statistics. Also, the end of the interruption was not recorded if the interrupting device was closed automatically (in practice referred to as "autoreclosing"). The collection of data for these interruptions requires automatic registration, either of voltages at the customer connection or of switching actions in the network. As the duration of interruptions terminated by autoreclosing is much shorter than interruptions terminated manually, the former are referred to as "short interruptions".

Apart from the difficulties in recording automatically-terminated interruptions, there are other reasons for treating these interruptions differently. The aim of the autoreclosing scheme is to prevent customers from experiencing long interruptions with durations of several hours or more. Instead, the customers experience short interruptions, with durations between a few seconds and a few minutes. In many cases, the autoreclosing scheme is such that the customer experiences more short interruptions with the scheme than long interruptions without the scheme. Traditionally, for many customers, the impact of a 1-minute interruption is negligible or at least, much less than the impact of a 1-hour interruption. The result of the autoreclosing scheme has therefore traditionally been a reduction of the total inconvenience for customers. Due to a number of developments, beyond the scope of this report, the situation has changed.

However, the impact is strongly dependent on the type of customer, with industrial and commercial customers typically being impacted more than domestic customers. For a growing number of customers, especially industrial customers, even 1-minute interruptions are of similar concern as a longer interruption. Therefore, the need has arisen for information on the number and duration of short interruptions.

In some countries, a further distinction between short interruptions and transient interruptions is made, where the transient interruptions are interruptions of up to a few seconds. The reason for this distinction is partially due to the difference in origin between short and transient interruptions and partly due to the difference of the impact of the interruptions on customers. The impact of transient interruptions is typically less, but in cases of large motor loads a transient interruption may lead to equipment damage when there is insufficient coordination between the motor protection and the autoreclosure scheme. Also, damage to electronic equipment due to transient interruptions has been reported.

2.1.5 Component outages, incidents and supply interruptions

When studying continuity of supply, it is very important to consider the difference between *"component outages"* (in short: outages) and "*supply interruptions*" (in short: interruptions). As mentioned earlier, a supply interruption is a situation where a customer is without electricity. An outage is a situation where a component in the power network (e.g., a cable or a transformer) is disconnected from the rest of the network. This may be due to a fault resulting in the removal of the component, due to a component failure resulting in an open circuit, due to an unintended switching operation (i.e. human error) or even due to an intended switching operation.

Supply interruptions are, in all cases, due to component outages. However, not all component outages result in supply interruptions. The start of an interruption is typically due to the start of an outage (a "component failure"). The end of an interruption may be due to a switching operation or the end of a component outage (component restoration, repair or replacement).

An outage that results in an interruption for one or more customers is referred to as an *"incident"*. It is important to distinguish between the incident, which takes place in the network, and the interruption, which takes place at the customer's connection point. The majority of customers are connected to the low voltage network, but a substantial number of the interruptions experienced by low voltage customers is due to incidents that occur at higher voltage levels. For most low voltage (LV) and medium voltage (MV) customers, the majority of interruptions are due to incidents that occur at medium voltage level.

In radial networks (typically at low or medium voltage in remote locations) there is only one supply path to the customers. The outage of a component will immediately result in an interruption and the interruption will only end when the component is restored. In that case, the interruption exactly corresponds to the outage. The duration of the interruption is equal to the time needed to restore, repair or replace the failed component.

In more complex networks (most of the remainder of low and medium voltage networks), an alternative path exists but is not used during the operation. Such networks are sometimes referred to as "radial operated meshed networks". The start of an interruption corresponds with the start of an outage, but the interruption can be ended (electricity restored) through a switching action ("back feeding"). This is referred to as "redundancy through switching".

In sub-transmission and transmission networks and in important medium voltage networks, the alternative path not only exists but is also used during the operation. The electric power flows through both paths and after an outage in one of the paths, the other path takes over immediately. The customers will not experience any interruption. This is referred to as "redundancy through parallel operation".
The presence of redundancy significantly improves the continuity of supply, but it can also significantly increase the costs.

2.1.6 Exceptional events

Some interruptions are considered to be due to exceptional events and therefore 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. The underlying reasons for the decision also differ between countries, but in general, are based on the consideration that it is not possible to design a power system that can cope with any situation.

Exceptional weather or other circumstances can result in component failure even if the components are designed correctly, using reasonable safety margins. Such outages are often considered to be outside of the control of the system operator. This may be, for example, intentional damage to network components, like vandalism, or very extreme weather conditions.

It should be noted, however, that weather circumstances that occur occasionally should not be considered as exceptional events. For example, snowstorms are not an exceptional event in Sweden, but could be seen as an exceptional event in southern Greece. Similarly, very hot temperature for sustained periods of time is not an exceptional event in Greece, but could be considered so in Sweden. Lightning should not be treated as an exceptional event anywhere in Europe.

The second situation that is considered exceptional is when external circumstances result in a large number of component outages during a short period of time. The normal redundancy present in the system will be far from sufficient. The number of repair crews will not be sufficient to quickly repair all components. This is typically the case with exceptional weather, such as hurricanes. At the same time, the high winds, heavy snow, flooding or other extreme weather conditions, will make it impossible to repair the components.

Exceptional events will be discussed in more detail in section 2.7.

2.1.7 Use of continuity data

The way in which continuity data is used is important in determining what data should be collected, which indices should be calculated using the data, and how the results should be presented.

Continuity data can be used in a number of ways, most of which are outside of the scope of this report. Examples of the use of continuity data are:

- Finding an absolute value of the performance of a given network during a given year. For example, to compare the performance with a performance target;
- Giving information to individual customers or groups of customers on the level of continuity that can be expected;
- Detecting trends in network performance by making year-by-year comparisons of the continuity indices;
- Comparing different groups of customers or different parts of the network;
- Giving feedback to the system operator for maintenance planning and investment decisions;
- Comparing the performance of different types of networks, different system operators or different countries;
- Providing information which can be used in incentive-based regulation.

In this report, the comparison will be made by using continuity indices that may have been developed for other purposes than for benchmarking between countries. Different countries have different reporting rules, somewhat different definitions of interruption, various definitions and treatment of exceptional events and also use somewhat different indices. This explains, in part, the difficulty in quantitatively comparing results from different countries. Part of the difference is also due to geographic and climate differences between countries: customer density and weather influences show large differences throughout Europe. In addition, different methods for design, grounding, operation and maintenance result in differences in continuity indices.

The fact that many system operators collect data on continuity of supply for their own internal use shows the usefulness of this data for purposes other than reporting to a regulator. The collection of this kind of data long precedes its use for regulatory purposes.

2.2 Main Conclusions from Previous Benchmarking Reports on Quality of Electricity Supply

The main features of continuity of supply, across several surveyed countries, are described in the 1st (April 2001), 2nd (September 2003) and 3rd (December 2005) Benchmarking Reports on quality of electricity supply[2].

2 All previous Benchmarking Reports are freely available on the website: www.energy-regulators.eu.

In brief, the 1st Benchmarking Report identified the two main features of continuity of supply regulation as (1) guaranteeing that each user can be provided with at least a minimum level of quality and (2) promoting quality improvement across the system. The comparative analysis of available measurement and continuity of supply regulation in the 1st Benchmarking Report shows that regulators have generally approached continuity issues by starting with long interruptions affecting low voltage customers, treating planned and unplanned interruptions separately. In several countries, both the number and the duration of interruptions are available, but the choice of the indicator used varies by country. In many countries, short interruptions are or will be recorded as well. Different approaches to continuity of supply regulation, and in particular the different continuity indicators and standards adopted, recording methodologies used, combined with different geographical, meteorological and network characteristics, make benchmarking of actual levels of continuity of supply difficult.

In the 2nd Benchmarking Report, the number of countries included in the comparison was extended and the comparisons were more detailed. Distinctions were made between planned and unplanned interruptions, different voltage levels and load density areas as well as a classification of the interruption by its cause. It was noted that further harmonisation of data and definitions between regulators remained necessary.

For unplanned interruptions, it was shown that some countries with historically high levels of continuity of supply were experiencing more and longer interruptions. On the contrary, some countries with historically lower continuity of supply showed significant improvements.

The 2nd Benchmarking Report also concluded that no relevant signals of quality of supply decreases were emerging in European countries, even after the privatisation of utilities, increasing supply competition, price-cap regulation for monopolistic activities and legal unbundling of businesses.

A number of encouraging trends were observed in the 3rd Benchmarking Report:

- The duration of unplanned interruptions showed (for most countries) a significant downward trend;
- The number of unplanned interruptions showed (for most countries) a downward trend;
- Excluding exceptional events from unplanned performance figures highlighted the significant improvements being made by many European countries in terms of both the duration and the number of interruptions;
- Countries with previously low levels for the duration and number of interruptions have made further improvements; and
- The number of short interruptions has generally not risen, despite an increased move towards automation and remote control techniques.

2.3 Continuity of Supply Monitoring

The continuity of supply is monitored in all countries that replied to the survey. The kind of interruptions monitored and the level of detail being reported varies significantly between countries. An overview of these differences is presented in this section.

Not all countries replied to the survey. For some of those countries, we are aware of detailed monitoring programmes. For other countries, we are not aware of such programmes.

2.3.1 Types of interruptions monitored

Table 2.1 shows the kinds of interruptions that are monitored in the different countries. Unplanned interruptions of long duration are monitored in all countries even if not all countries monitor these interruptions at all voltage levels (see section 2.4.2); planned interruptions are not monitored in Belgium (Federal). The only system operator this applies to is the Belgium transmission system operator (networks with nominal voltages of 30 kV and higher).

TABLE 2.1 TYPES OF INTERRUPTIONS MONITORED IN THE DIFFERENT COUNTRIES

Country	Long interruptions	Short interruptions	Transient interruptions	Unplanned interruptions	Planned interruptions
Austria	X			X	X
Belgium (Brussels region)	X			X	X
Belgium (Flemish region)	X	X		X	X
Belgium (Walloon region)	X			X	X
Belgium (Federal)	X	X		X	
Czech Republic	X			X	X
Denmark	X(4)	X(4)		X	X
Estonia	X			X	X
Finland	X	X		X	X
France	X	X	X(2)	X	X
Germany	X			X	X
Hungary	X	X	X	X	X
Italy	X	X	X	X	X
Lithuania	X	X		X	X
Luxembourg	X			X	X
the Netherlands	X			X	X(3)
Norway	X	X		X	X
Poland	X	X		X	X
Portugal	X	X(1)		X	X
Romania	X			X	X
Slovenia	X			X	X
Spain	X	X		X	X
Sweden	X			X	X
United Kingdom	X	X		X	X

(1) In Portugal, all interruptions (including short ones), are monitored at transmission level. But in accordance with the quality of service code, only long interruptions are reported.
(2) In France, the TSO monitors transient interruptions, but does not calculate any specific indicators for transient interruptions.
(3) In the Netherlands, planned interruptions are only monitored from 2006.
(4) In Denmark, all interruptions lasting 1 minute or more are monitored.

Short interruptions are recorded by 12 of the 24 respondents (Belgium gave four different replies); 3 countries record transient interruptions separately, but only 2 countries (Hungary and Italy) calculate indices for transient interruptions. The definitions regarding the duration of long, short, and transient interruptions which are monitored are reported for different countries in Tables 2.2a and b.

TABLE 2.2A DEFINITIONS OF LONG, SHORT AND TRANSIENT INTERRUPTIONS

Country	Transient interruption	Short interruption	Long interruption
Austria			T>3 min
Belgium (Brussels region)			T>3 min
Belgium (Flemish region)		T≤3 min	T>3 min
Belgium (Walloon region)		T<3 min	T≥3 min
Belgium (Federal)		T<3 min	T≥3 min
Czech republic	T≤1 sec	1 sec <T≤3 min	T>3 min
Denmark		T≤3 min	T>3 min
Estonia			T>3 min
Finland		T≤3 min	T>3 min
France	T<1 sec	1 sec ≤T<3 min	T≥3 min
Germany			T>3 min
Hungary	T≤1 sec	1 sec <T≤3 min	T>3 min
Italy	T≤1 sec	1 sec <T≤3 min	T>3 min
Lithuania		1 sec ≤T<3 min	T≥3 min
Luxembourg			T>3 min
the Netherlands			T>1 min
Norway		T≤3 min	T>3 min
Poland	T≤1 sec	1 sec < T ≤3 min	T>3 min
Portugal		T≤3 min	T>3 min
Romania	T≤1 sec	1 sec <T≤3 min	T>3 min
Slovenia		T≤3 min	T>3 min
Spain	T≤0.5 sec	0.5 sec <T≤3 min	T>3 min
Sweden		T≤3 min	T>3 min
United Kingdom		T<3 min	T≥3 min

TABLE 2.2B DEFINITIONS OF LONG, SHORT AND TRANSIENT INTERRUPTIONS

Country	Transient interruption	Short interruption	Long interruption
Austria Belgium (Brussels region) Estonia Germany Luxembourg			T>3 min
Belgium (Flemish region) Denmark Finland Norway Portugal Slovenia Sweden		T≤3 min	T>3 min
Belgium (Federal) Belgium (Walloon region) Lithuania United Kingdom		T<3 min	T≥3 min
Czech republic Hungary Italy Poland Romania	T≤1 sec	1 sec <T≤3 min	T>3 min
France	T<1 sec	1 sec ≤T<3 min	T≥3 min
the Netherlands			T>1 min
Spain	T≤0.5 sec	0.5 sec <T ≤3 min	T>3 min

2.3.2 Voltage levels monitored

In different countries, incidents at different voltage levels are monitored, as shown in Table 2.3. Incidents at the MV level are monitored in all countries. The regulation in Belgium (Federal) only applies to high voltage (HV) and transmission networks. Incidents in the HV network are monitored in all countries, with the exception of Belgium (Walloon region) and Slovenia. Incidents in the LV network are monitored in 16 of the 21 countries. Incidents in the transmission network are monitored in 14 of the 21 countries. Incidents at all voltage levels are monitored in 12 countries.

The lack of monitoring at LV level could result in a significant underestimation of the number and duration of interruptions experienced by low voltage customers, especially in urban areas, but even at national levels. Indeed, even if each incident in LV will affect much fewer customers than each incident in MV and higher voltage levels, incidents at LV cannot be neglected, as the resulting interruptions often last longer than interruptions due to incidents at higher voltage levels and are also important in number. For instance in Italy, from 1999 to 2007, on average 7% of SAIFI and 22% of SAIDI[3] were due to incidents at LV level. In Hungary from 2003-2006, 19% of SAIFI and 30% of SAIDI were due to incidents at LV level. For the United Kingdom from 2003-2006, the contribution from LV was 13% of CIs and 28% of CML.

3 See definitions, section 2.4

TABLE 2.3 VOLTAGE LEVELS MONITORED IN THE DIFFERENT COUNTRIES

Country	LV	MV	HV	Transmission
Austria		X	X	
Belgium (Brussels region)		X	X	
Belgium (Flemish region)				
Belgium (Walloon region)		X		
Belgium (Federal)			X	X
Czech Republic	X	X	X	
Denmark	X	X	X	X
Estonia	X	X	X	
Finland	X(1)	X	X	X
France	X	X	X	X
Germany	X	X	X	X
Hungary	X	X	X	X
Italy	X	X	X	X
Lithuania	X	X	X	X
Luxembourg		X	X	
the Netherlands	X	X	X	X
Norway(2)		X	X	X
Poland	X	X	X	X
Portugal	X	X	X	X
Romania	X	X	X	X
Slovenia		X		
Spain	X	X	X	
Sweden	X	X	X	X
United Kingdom(3)	X	X	X	

(1) In Finland, only the number of interruptions is monitored at LV.
(2) In Norway, all interruptions due to incidents in networks with voltage levels above 1 kV are included in the statistics. This includes also the effects on end-users connected to LV. Further the voltage level of the incident is reported.
(3) In the United Kingdom, unplanned incidents are monitored up to 132 kV; planned incidents up to 66 kV.
The regulator further monitors the following incidents:
- Incidents on the systems of one of the TSOs;
- Incidents on the systems of distributed generators; and
- Incidents on any other connected systems – which should be identified.

2.3.3 Level of detail in the calculated indicator

Continuity of supply indicators can be calculated for a country or region as a whole, for each system operator, for each feeder, or even for each individual customer. The practice varies strongly between different countries, as shown in Table 2.4 and the associated notes. Most countries present the results for the whole country and per system operator (DSO/TSO). Belgium (Brussels Region) has only one system operator. In Belgium (Federal), the regulation only applies to the TSO.

In a small number of countries, the indicators are calculated per region, per feeder or per customer. Further distinctions can be made based on the voltage level at which the incident takes place or on the cause of the incident. A distinction based on voltage level is made in 18 of the 21 countries. Information on the cause of the incident is given in 10 countries. However, the classifications used for the voltage levels and causes are significantly different between the different countries.

7 countries give separate indicators for rural and urban areas; 5 countries distinguish between underground and overhead ("aerial") networks. Also here, different countries use different classifications.

The questionnaire to regulators further asked if data was available for the continuity of supply in large cities. Such data is available from the following regulators: Belgium (Brussels region); Finland, Germany, Italy, Luxembourg, Norway and Sweden.

TABLE 2.4 LEVEL OF DETAIL IN THE PRESENTATION OF THE INDICATORS IN THE DIFFERENT COUNTRIES

Country	National	System Operators	Region	Feeder	Customer	Voltage level	Causes	Urban/ rural	Cable/ aerial
Austria	X	X				X[10]	X		
Belgium (Brussels region)			X			X[34]	X[16]		
Belgium (Flemish region)		X				X[6]	X		
Belgium (Walloon region)		X					X[17]		X
Belgium (Federal)	X		X			X[7]	X[18]		
Czech Republic	X	X	X		X	X[11]			
Denmark	X	X		X[38]	X[38]	X[39]	X[40]		X[41]
Estonia	X					X[33]			
Finland	X	X		X[3]		X[32]			
France	X	X	X		X[1]	X[2]	X[19]		
Germany	X					X[8]	X		
Hungary	X	X				X[12]			
Italy	X	X	X	X[26]	X	X[9]	X	X[22]	X[26]
Lithuania	X	X				X[35]	X[36]	X[37]	
Luxembourg	X					X[28]			
the Netherlands	X	X				X[30]	X		
Norway[5]	X	X	X		X	X[13]	X[20]		X[27]
Poland	X	X							
Portugal	X	X	X		X	X[29]		X[23]	
Romania	X	X				X[4]		X	
Slovenia	X	X		X				X[31]	
Spain	X	X	X			X[14]		X[24]	
Sweden	X	X							
United Kingdom	X	X		X		X[15]	X[21]	X[25]	X[25]

Footnotes to table 2.4

(1) In France, continuity indicators are monitored at single-customer level, for each kind of customer, especially following contractual commitments of industrial customers, railway operators and distribution operators.

(2) In France, the following classification is used:
For the TSO: from 50 kV to 400 kV;
EHV: 400 kV;
HV: 225 kV, 150 kV, 90 kV and 63 kV.
For the DSOs: at 50 kV or less;
MV: 20 kV and 15 kV;
LV: 400 V and 230 V.
However, in certain cases, the DSO is in charge of certain lines of HV grid.

(3) In Finland, continuity indicators are monitored at MV transformer district level.

(4) In Romania, continuity indicators are recorded according to the following classification of voltage levels:
- LV, up to and including 1 kV;
- MV, above 1 kV and up to 110 kV;
- HV, 110 kV;
- Transmission, above 110 kV.

(5) In Norway, the interruption data is collected at a single-customer level where customers are divided into 27 different groups. The indicators are then calculated and reported based on customer category, DSO/TSO, region (county) and for the whole country.

(6) In Belgium (Flemish region), a distinction is made between HV and MV.

(7) In Belgium (Federal), a classification is made according to the voltage at the point of delivery:
- MV;
- 30-70 kV;
- 150-380 kV.

(8) In Germany, the following classification is used of the voltage level at which the incident took place:
- EHV: above 125 kV;
- HV: above 72.5 kV up to and including 125 kV;
- MV: above 1 kV up to and including 72.5 kV;
- LV: 1 kV or lower.

(9) In Italy, the following classification is used:
- Transmission;
- HV (above 35 kV);
- MV (above 1 kV);
- LV (up to 1 kV).

Incidents with transformers are attributed to the lower voltage level if the incident does not cause an interruption for the higher voltage level.

(10) In Austria, the voltage level of the incident is classified according to:
- EHV: above 110 kV;
- HV: above 36 kV up to and including 110 kV;
- MV: above 1 kV up to and including 36 kV;
- LV: 1 kV or lower.

(11) In the Czech Republic, a distinction is made between
- LV: less than 1 kV;
- MV: between 1 kV and 35 kV;
- HV: between 35 kV and 400 kV.

(12) In Hungary, distinction is made between
- LV: 0.4 kV;
- MV: 10 up to 35 kV;
- HV: 120 kV;
- Transmission: 220 up to 750 kV.

(13) The following classification is used in Norway in the interruption statistics as regards which voltage level the incidents occur:
- $1 < U \leq 22$ kV;
- $33 \leq U \leq 110$ kV;
- 132 kV;
- $220 \leq U \leq 300$ kV;
- 420 kV.

(14) In Spain, a distinction is made between distribution (up to 220 kV) and transmission (220 kV and higher).

(15) In the United Kingdom, the following classification is used of the voltage level at which the incident took place:
- Transmission (275 and 400 kV);
- 132 kV;
- 66 kV;
- 33 kV;
- 22kV;
- 20 kV;
- 11 kV;
- 1kV to 6.6 kV;
- 400 V.

(16) In Belgium (Brussels region), interruptions are classified in the following categories based on the cause:
- HV or MV cable not caused by a third party;
- HV or MV cable caused by a third party;
- HV or MV overhead line in normal weather conditions;
- HV or MV overhead line as a result of bad weather conditions or caused by a third party;
- HV station or MV transformer station of the DSO at the HV or MV side;
- HV station or MV transformer station of a grid-user;
- Fault on another electricity grid not managed by the DSO.

(17) Most DSOs in Belgium (Walloon region) use the following classification:
- Electrical;
- Weather;
- External intervention (subcontractors);
- External component;
- External influence;
- Technology, building method;
- Operations;
- Others.

(18) The following classification is used by the TSO (the only company under the federal regulator in Belgium) for reporting to the regulator:
- Fault on a cable connection operated by the TSO, all causes except cable rupture by third parties;
- Fault on a cable connection operated by the TSO caused by third parties;
- Fault on a HV line operated by the TSO, all causes except weather conditions;
- Fault on a HV line operated by the TSO caused by weather conditions;
- Fault on a HV substation operated by the TSO;
- Fault in an external network, in the customer's installations;
- Fault in an external network, located in a distribution or transmission system that is not operated by the TSO.

(19) The following classification is used by the TSO in France:
- Atmospheric events (lightning, snow, wind…);
- Hardware events (line, substation…);
- Vegetation contact;
- Human operation cause;
- Customer installation cause;
- Third party cause;
- Non-identified cause.

(20) The following main classification after cause is used in Norway. These main categories are further divided into subcategories:
- Surroundings;
- People (staff);
- People (others);
- Operational stress;
- Technical equipment;
- Design/installation;
- Others.

(21) The UK regulator requires the network operators to report interruptions according to the following causes:
- Lightning;
- Rain, snow, sleet, blizzard, freezing fog, frost and ice;
- Wind, gale, growing trees, falling trees and wind-borne materials;
- All other causes due to weather and environmental causes plus birds, animals and insects;
- Company and manufacturer causes;
- Third party;
- Any other causes (including unknown and unclassified).

(22) In Italy, data is reported separately for 300 districts, where a classification is made between:
- Urban: high-density municipalities, more than 50,000 inhabitants;
- Semi-urban: medium-density municipalities, between 5,000 and 50,000 inhabitants;
- Urban: low-density municipalities, less than 5,000 inhabitants.

(23) In Portugal, data is reported separately for rural, semi-urban and urban areas based on the following rules:
- Urban: zone A, main cities and localities with more than 25,000 customers;
- Semi-urban: zone B, localities with 2,500 to 25,000 customers;
- Rural: zone C, localities with less than 2,500 customers.

(24) The following area classification is used in Spain:
- Urban area: all those municipal districts in a province with more than 20,000 customers, including provincial capital cities even though they do not reach 20,000 customers;
- Semi-urban area: all of the municipal districts in a province with a between 2,000 and 20,000 customers, excluding provincial capital cities;
- Rural area:
  - Concentrated rural area: all those municipal districts in a province with between 200 and 2,000 customers;
  - Scattered rural area: all those municipal districts in a province with fewer than 200 customers as well as the customers located outside the population centres that are not industrial or residential.

At the request of the distribution company affected, the Ministry of Economy may redefine the areas.

(25) The UK regulator collects physical characteristics and performance information for each MV circuit for each distribution company. These circuits are then divided into 22 circuit groups with physically similar characteristics. The groups are defined so that differences in the percentage of overhead line, circuit length and number of connected customers are minimised and that no group is dominated by a single company. The regulator compares and benchmarks the performance within each circuit group.

(26) In Italy, data on cable and aerial networks is collected per single MV feeder but not published.

(27) In Norway, data is reported separately for:
- Distribution network - overhead lines (more than 90% of the feeder km is overhead);
- Distribution network - cables (more than 90% of the feeder km is underground);
- Distribution network - mixed;
- Regional grid;
- Central grid.

(28) In Luxembourg, a distinction is made between:
- LV: 1 kV and less;
- MV: above 1 kV but less than 65 kV.

(29) In Portugal, the following voltage levels are distinguished
- LV: 1 kV or less (in practice: 400 V);
- MV: higher than 1 kV up to and including 45 kV (6, 10, 15 and 30 kV);
- HV: above 45 kV up to and including 110 kV (60 kV);
- EHV: above 110 kV (130, 150, 220 and 400 kV).

(30) In the Netherlands, continuity indicators are recorded according to the following classification of voltage levels:
- LV: ≤ 1 kV;
- MV: > 1 kV and < 35 kV;
- HV: ≥ 35 kV and < 220 kV;
- EHV: ≥ 220 kV.

(31) The following area classification is used in Slovenia:
- Urban settlements are all settlements in Slovenia that have more than 3,000 inhabitants;
- Urban settlements are settlements that have between 2,000 and 2,999 inhabitants and a surplus of workplaces over the number of persons in employment;
- Urban settlements are centres of municipalities that have at least 1,400 inhabitants and a surplus of workplaces over the number of persons in employment;
- Urban settlements are also settlements in urban areas that are determined on the basis of a combination of criteria;
- All other areas are classified as rural areas.

(32) In Finland, interruption data is collected from the DSO (mostly at MV level in 10 and 20 kV and only the total number of interruptions in the LV level in 0.4 kV) and from the so-called area network companies and from the TSO (both the area network companies and TSO at 110 kV, 220 kV and 400 kV level). Furthermore, LV level is up to 1 kV, MV level is up to 70 kV. 110 kV can be part of the HV- or transmission network depending of the usage of the power line. 220 kV and 400 kV are the transmission network lines.

(33) In Estonia, continuity indicators are recorded according to the following classification of voltage levels:
- 110 kV and lower (in practice 0.4 to 35 kV);
- Higher than 110 kV.

(34) In Belgium (Brussels region), a distinction is made between HV and MV; in the future also LV will be reported separately.

(35) In Lithuania, the following classification is used:
- Transmission (110 kV and higher);
- MV (above 1 kV up to 35 kV);
- LV (up to 1 kV).

Incidents with transformers are attributed to the lower voltage level if the incident does not cause an interruption for the higher voltage level.

(36) The following classification is used by the TSO and DSO in Lithuania:
- "force majeure" causes (for instance: extreme weather conditions, fire, war, terrorist act and extreme conditions which could be attributed to "force majeure" according to legal acts provisions);
- External (or third party) causes;
- Causes attributable to System operator responsibility;
- Non-identified causes.

(37) In Lithuania, data is reported separately for each DSO, where a classification is made between:
- Urban: cities, small towns and all compact settlements that have more than 500 inhabitants or have described indication (according to legislation) of small town or township;
- Rural: all other areas.

(38) In Denmark, LV interruptions are monitored at radial level, MV, HV and transmission interruptions are monitored at delivery point level (10-20/0.4kV distribution transformer). Regulator has in some cases made an exemption for some DSOs, so that the DSO is allowed to estimate the number of customers under each delivery point (10-20/0.4 kV transformer) and/or under each LV-radial. SAIDI and SAIFI are calculated for each voltage level based on the number of customers on each voltage level.

(39) The following classification is used for voltage levels in Denmark:
- Transmission (>170 kV);
- HV (25-70 kV and 70-170 kV);
- MV (6-25 kV);
- LV (up to 1 kV).

(40) In Denmark interruptions are divided into the following causes:
- Meteorology;
- Other External;
- Operation and Maintenance;
- Materials;
- Other.

(41) In Denmark, interruptions are monitored for underground cables (including sea cables) and aerial lines. Data is registered in the EL-FAS fault statistics. These categories are not included in the Danish regulators guide for monitoring interruptions and therefore not reported to the regulator.

2.4 Continuity of Supply Indicators

2.4.1 Indices for distribution systems

At distribution level, the following indices are in use in the countries that replied to the questionnaire.

SAIDI, or System Average Interruption Duration Index, gives the average amount of time per year that the supply to a customer is interrupted. It is expressed in minutes per customers per year and calculated by using the following expression:

$$\text{SAIDI} = \frac{\sum_i N_i x\, r_i}{N_T}$$

where the summation is taken over all incidents, either at all voltage levels or only at selected voltage levels; r_i gives the restoration time for each incident; N_i gives the number of customers interrupted by each incident; N_T gives the total number of customers in the system for which the index is calculated. (Note that the restoration time is different for different groups of customers involved in the same incident; therefore, the sum must be extended to each group of customers experiencing the same restoration time).

SAIFI, or System Average Interruption Frequency Index, gives the average number of times per year that the supply to a customer is interrupted. It is expressed in interruptions per customer per year and calculated using the following expression:

$$\text{SAIFI} = \frac{\sum_i N_i}{N_T}$$

CAIDI, or Customer Average Interruption Duration Index, gives the average duration of an interruption. It is expressed in minutes per interruption and calculated using the following expression:

$$\text{CAIDI} = \frac{\sum_i N_i x\, r_i}{\sum_i N_i}$$

It can also be obtained as the ratio of SAIDI and SAIFI.

These three indices (SAIDI, SAIFI and CAIDI) are the main indices used in the majority of countries. These indices are defined among others in IEEE Std.1366, where weighting based on number of customers is used. With both SAIFI and SAIDI, a reduction in value indicates an improvement in the continuity of supply. With CAIDI this is not the case: a reduction in both SAIDI and SAIFI could still result in an increase in CAIDI. Whereas CAIDI remains a useful index, it is not suitable for comparisons or for trend analysis.

The above expressions for SAIDI, SAIFI and CAIDI hold for weighting of the interruptions based on number of customers. As shown in Table 2.6, several other weighting methods are also in use. In that case the expressions (in the equations) change somewhat.

- For weighting based on interrupted power, N_i gives the amount of rated or contracted power interrupted by each incident; N_T gives the total rated or contracted of the system for which the index is calculated. The "rated or contracted power" may be the rated power of transformers (typically distribution transformers) or the contracted power of MV or HV customers.
- For weighting based on undelivered energy, N_i gives the amount of active power interrupted by each incident; N_T gives the total active power consumption of the system for which the index is calculated.
- For weighting based on number of distribution transformers, N_i gives the number of distribution transformers interrupted by each incident; N_T gives the total number of distribution transformers in the system for which the index is calculated.
- For weighting based on the number of delivery points, N_i gives the number of delivery points interrupted by each incident; N_T gives the total number of delivery points in the system for which the index is calculated.
- For weighting based on annual energy consumption, N_i is the annual energy consumption of the customers interrupted by each incident; N_T gives the annual energy consumption of the system for which the index is calculated.

CI, or Customer Interruptions, is used in United Kingdom instead of SAIFI. It is calculated in the same way as SAIFI but expressed as the number of interruptions per 100 customers per year.

CML, or Customer Minutes Lost, is used in United Kingdom as synonym for SAIDI.

ASIDI, or Average System Interruption Duration Index, gives the average duration of an interruption, weighted by the rated or contracted power rather than by the number of customers affected. It is expressed in minutes per year, and calculated using the following expression:

$$\text{ASIDI} = \frac{\sum_i L_i x \, r_i}{L_T}$$

where the summation is taken over all incidents, either at all voltage levels or only at selected voltage levels; r_i gives the restoration time for each incident; L_i gives the rated or contracted power interrupted by each incident; L_T gives the total rated or contracted or interrupted power in the system for which the index is calculated. The "rated or contracted power" may be the rating of a distribution transformer, the contracted power of an MV or HV customer, or the transformer rating in a delivery point.

T-SAIDI, or Transformer SAIDI, is used in Finland for SAIDI weighted by the annual energy consumption.

T-SAIFI, or Transformer SAIFI, is used in Finland for SAIFI weighted by the annual energy consumption.

ASIFI, or Average System Interruption Frequency Index, gives the average number of interruptions weighted by the rated or contracted power rather than by the number of customer affected. It is expressed in number of interruptions per year and calculated using the following expression:

$$\text{ASIFI} = \frac{\sum_i L_i}{L_T}$$

CAIFI, or Customer Average Interruption Frequency Index, gives the average number of long interruptions during a given year for those customers that experience at least one long interruption during that year. Like SAIFI, it is expressed in interruptions per customer per year. The value of CAIFI is equal to one or larger. It is calculated using the following expression:

$$\text{CAIFI} = \frac{\sum_i N_i}{CN}$$

with CN, the total number of customers that have experienced at least one interruption during the reporting year.

CTAIDI, or Customer Total Average Interruption Duration Index, gives the total amount of time per year that the supply is interrupted for those customers that experienced at least one interruption during the reporting year. Like SAIDI, it is expressed in minutes per customer per year. It is calculated by using the following expression:

$$\text{CTAIDI} = \frac{\sum_i N_i \, x \, r_i}{CN}$$

ENS, or Energy Not Supplied, gives the total amount of energy that would have been supplied to the interrupted customers if there would not have been any interruptions. It is calculated by adding the non-supplied energy due to each incident:

$$\text{ENS} = \sum_i E_i$$

with E_i the energy not supplied due to each incident.

TIEPI, or "equivalent interruption time related to the installed capacity", is used in Spain and Portugal to quantify the average time during which the supply to a customer is interrupted. TIEPI is calculated by using the following expression:

$$\text{TIEPI} = \frac{\sum_i S_i x r_i}{S_T}$$

where S_i is the sum of the rating of all interrupted MV/LV transformers plus the contracted power of all interrupted MV and HV customers, and S_T the total rating of all MV/LV transformers plus the total contracted power of all MV and HV customers connected to the system.

NIEPI, or "equivalent number of interruptions related to the installed capacity", is used in Spain as an alternative for SAIFI to quantify the average number of supply interruptions. NIEPI is calculated using the following expression:

$$\text{NIEPI} = \frac{\sum_i S_i}{S_T}$$

END, or Energy Not Distributed, is used in Portugal. It is calculated using the following expression:

$$END = E_T \, x \, \frac{TIEPI}{T}$$

with E_T the total inflow of energy into the distribution network during the reporting year, and T the number of hours during the reporting year (8760 or 8784).

In Italy, a new method for recording **the number of interruptions experienced by customer category** has been introduced from 2008. Each distribution system operator must provide the data indicated in Table 2.5.

TABLE 2.5 DISTRIBUTION OF NUMBER OF INTERRUPTIONS FOR INDIVIDUAL CUSTOMERS USED IN ITALY FROM 2008

	Number of long interruptions										
	0	1	2	3	4	5	6	7	8	9	>9
No. of LV customers											
No. of MV customers											
	Number of long + short interruptions										
	0	1	2	3	4	5	6	7	8	9	>9
No. of MV customers											

Separate tables are required, per territorial district, for:

- LV customers and MV customers (separately): Number of long unplanned interruptions (all voltage levels, excluding force majeure and third party damage).
- MV customers (only): Number of long and short unplanned interruptions (all voltage levels, excluding force majeure and third party damage).

2.4.2 Indices for transmission systems

In addition to the indices mentioned in the previous section, the following indices are used to quantify the continuity of supply at transmission level.

AIT, or Average Interruption Time, is a measure for the amount of time that the supply is interrupted. It is expressed in minutes per year and calculated by using the following expression:

$$AIT = \frac{60 \, x \sum_i E_i}{P_T}$$

where P_T is the average power supplied by the total system (in MW) and E_i the non-supplied energy (in MWh) for each incident.

AIF, or Average Interruption Frequency, is a measure for the number of times per year that the supply is interrupted. It is expressed in interruptions per customer per year and calculated by using the following expression:

$$\text{AIF} = \frac{\sum_i P_i}{P_T}$$

with P_i the power interrupted by each incident (in MW).

AID, or Average Interruption Duration, is a measure for the average duration of an interruption. It is expressed in minutes per interruption and calculated by using the following expression:

$$\text{AID} = \frac{60 \times \sum_i E_i}{\sum_i P_i}$$

SARI, or System Average Restoration Index, is used in Portugal to quantify the average duration of an interruption. It is calculated separately for the transmission network considering the interruption in the delivery points by using the following expression:

$$\text{SARI} = \frac{\sum_i r_i}{NI}$$

where *NI* is the total number of interruptions and r_i is the duration of each interruption *i*.

END, is used as a synonym for ENS at transmission level in Lithuania.

2.4.3 Indices for short interruptions

MAIFI, or Momentary Average Interruption Frequency Index, gives the average number of times per year that the supply to a customer is interrupted for a duration of 3 minutes or less. The term “momentary interruption” is used in North America as a synonym to short interruption. The upper limit of the duration of a short interruption varies between different countries from 1 minute through 3 minutes. The expression for calculating MAIFI is the same as the one for calculating SAIFI:

$$\text{MAIFI} = \frac{\sum_i N_i}{N_T}$$

where the summation is taken over all incidents resulting in short interruptions. Like SAIFI, MAIFI is expressed in number of interruptions per year. The discussion on different weighting methods, given before, can also be applied to MAIFI.

When calculating MAIFI, the so-called time-aggregation rules are very important. Multiple interruptions during a 3-minute period, due to automatic reclosing actions, may be counted as one event for MAIFI or as multiple events. This choice could significantly impact the value of MAIFI.

The terms **AIF**, (Average Interruption Frequency), **SI** (Short Interruptions) and **SAIFI_k** (“SAIFI short”) are used as synonym for MAIFI.

$\text{MAIFI}_{transient}$ is used in Italy to express the number of transient interruptions. It is defined in the same way as MAIFI and SAIFI, but the summation is only taken over those incidents that result in transient interruptions.

$SAIDI_k$, or “SAIDI short”, $SAIFI_k$ or “SAIFI short”, $CAIDI_k$, or “CAIDI short”, $CTAIDI_k$, or “CTAIDI short”, and $CAIFI_k$, or “CAIFI short” are used in Norway as the short interruption equivalents of SAIDI, SAIFI, CAIDI, CTAIDI and CAIFI. The definitions are the same as of the equivalents for long interruptions, but the summation only takes place over those interruptions that result in short interruptions.

2.4.4 Long interruptions

An overview of the different indices used in the different countries to quantify the number of long interruptions is given in Table 2.6. The definitions of the different indices are given in section 2.4.1 for distribution systems and in section 2.4.2 for transmission systems. The table also gives information on the weighting method used and on the rules used for measuring the duration of interruptions and number of customers involved. SAIDI and SAIFI are the most commonly-used indices with weightings in most countries based on the number of customers.

TABLE 2.6 INDICES FOR QUANTIFYING LONG INTERRUPTIONS USED IN THE DIFFERENT COUNTRIES

Country	Index	Weighting (n.a. for ENS)	Rules for measurements
Austria	ASIDI, ASIFI, ENS	Interrupted power, amount of energy not supplied.	The system operators are responsible for collecting the data. The regulator is only doing a plausibility check after receiving it. In practice SCADA is commonly used.
Belgium (Brussels region)	SAIDI, SAIFI, CAIDI	MV: number of distribution transformers. An improvement factor of 0.85 is used for transformer stations with a relatively high load. HV: amount of energy not supplied.	All HV customers are equipped with automatic meter reading.
Belgium (Flemish region)	SAIDI, SAIFI, CAIDI	MV: number of distribution transformers. An improvement factor of 0.85 is used for transformer stations with a relatively high load. HV: amount of energy not supplied.	All HV customers are equipped with automatic meter reading.
Belgium (Walloon region)	SAIDI, SAIFI, CAIDI	Number of customers	-
Belgium (Federal)	AIT, AIF, AID	Interrupted power	SCADA is used to determine opening of interrupting devices and duration of interruptions.
Czech Republic	SAIDI, SAIFI	Number of customers	-
Denmark	SAIDI, SAIFI, ENS	Number of customers ENS collected only for incidents above 100 kV	The Regulators guide for monitoring interruptions for distribution and regional transmission companies (3rd edition, March 2008).
Estonia	SAIDI, SAIFI, CAIDI	Number of delivery points.	-
Finland	SAIDI(2)		-
	T-SAIDI, T-SAIFI	Annual energy consumption.	

TABLE 2.6 INDICES FOR QUANTIFYING LONG INTERRUPTIONS USED IN THE DIFFERENT COUNTRIES

Country	Index	Weighting (n.a. for ENS)	Rules for measurements
France	SAIFI, ENS, AIT	SAIFI: number of delivery points ENS; AIT: interrupted power.	TSO: Logging of circuit-breaker opening and closing, registered by SCADA. DSO: The interruptions information system is connected with the MV and LV customers information system.
Germany	SAIDI, SAIFI	LV: number of customers MV, HV: nominal power.	-
Hungary	SAIDI, SAIFI	Number of customers	At MV and HV; SCADA should be used. At LV, estimating the number of customers interrupted is allowed.
Italy	Distribution: SAIDI, SAIFI(3) Number of interruptions per single MV customer Transmission: ENS, AIT SAIDI, SAIFI, (3)	Number of LV customers. Individual indicators, not weighted Number of transmission network users (final large customers, distributors, generators).	Connectivity models are required for all customers (1)
Lithuania	Distribution: SAIDI, SAIFI Transmission: ENS, AIT	Number of customers ENS, AIT - interrupted power	At HV and MV SCADA should be used. At LV, estimating the number of customers interrupted is allowed.
Luxembourg	SAIDI, SAIFI, ENS	SAIDI, SAIFI: number of customers ENS: interrupted power	
the Netherlands	SAIDI, SAIFI, CAIDI	Number of customers	
Norway	SAIDI, SAIFI, CAIDI, CTAIDI, CAIFI, ENS	SAIDI, SAIFI, CAIDI, CTAIDI and CAIFI are weighted on customers (end-user). ENS is calculated as a total value (4).	Standardised system for registration and reporting (FASIT) (5) applies for all companies. The network companies know exactly how many customers (end-users) are supplied from a reporting point (which is either a distribution transformer or an end-user connected above 1 kV).
Poland	SAIDI, SAIFI	Number of customers	-
Portugal	Transmission: ENS, AIT, SAIFI, SAIDI, SARI	SAIFI, SAIDI: number of delivery points. ENS, AIT: interrupted power.	MV, HV, EHV: SCADA should be used. LV: information is available on customer connectivity, but without phase information. For single-phase and two-phase interruptions the number of customers interrupted is estimated.

TABLE 2.6	INDICES FOR QUANTIFYING LONG INTERRUPTIONS USED IN THE DIFFERENT COUNTRIES		
Country	**Index**	**Weighting (n.a. for ENS)**	**Rules for measurements**
	MV: END, TIEPI, SAIDI, SAIFI	SAIDI, SAIFI: number of customers END, TIEPI: interrupted power.	
	LV: SAIDI, SAIFI	Number of customers	LV: information is available on customer connectivity, but without phase information. For single-phase and two-phase interruptions the number of customers interrupted is estimated.
Romania	Distribution: SAIDI, SAIFI, ENS, AIT Transmission: ENS, AIT	Number of customers	-
Slovenia	SAIDI, SAIFI	Number of customers	Connectivity models and SCADA
Spain	TIEPI, NIEPI	Capacity of the MV/LV transformers plus contracted power of MV customers.	Connectivity models are required for all customers.
Sweden	Distribution: SAIDI, SAIFI Transmission: ENS, AIT	Number of customers	-
United Kingdom	CI, CML	Number of customers	Connectivity models are required for all customers.

(1) For Italy, starting from 2000 and until 2007 an estimation method was permitted for LV customers:
a) For interruptions with origin on Transmission, HV and MV network: number of LV users affected = number of MV/LV transformers affected multiplied by the average number of LV users per MV/LV transformer (calculated at municipality level, taking account of different density areas);
b) For interruptions with origin in the LV network: number of LV users affected = number of LV lines affected multiplied by the average numbers of LV users per LV line (calculated at municipality level, taking account of different areas).
Starting from 2008, distribution companies are obliged to record the actual number (and the list) of LV customers involved in each long interruption. In order to meet this obligation, they are allowed to use information systems (e.g. SCADA and GIS) or smart meters and Automated Meter Management AMM systems. As from 2000, distribution companies must record the actual number (and the list) of HV and MV customers involved in each interruption (long, short and transient).

(2) In Finland, for LV incidents only the total number of the unexpected interruptions is collected and there is no weighting method used.

(3) In Italy, every distribution company reports the number of long unplanned interruptions during the reporting year for each MV customer. From 2008, distributions of number of interruptions will be reported in Italy, see section 2.4.5 for details. From 2008 the distribution system operators are obliged to record for each long unplanned interruption the number and the list of all low-voltage customers involved.

(4) In Norway, Energy not supplied is calculated separate for 27 different end-user groups. In the statistics ENS is given as a total value and per energy supplied, per end-user group, per end-user, per voltage level incidents occuring, per network level customers are connected at, etc.

(5) In Norway, a standardised system for registration and reporting of faults and interruptions called FASIT is used. It takes into account information about the network topology (NIS), customer information system (CIS), circuit breaker operations (e.g. from SCADA), load measurements and temperature data.

2.4.5 Short and transient interruptions

A number of countries that replied to the questionnaire gather data on short and transient interruptions. Information on the indices for short and transient interruptions used in these countries is summarised in Table 2.7. Definitions of the various indices are given in section 2.4.3. The number of short interruptions per year (MAIFI) is used in all countries, with the exception of Belgium (Flemish region), but under different names.

Some countries give separate indices for short and transient interruptions, others exclude transient interruptions; and some give one index covering short and transient interruptions. In Belgium (Flemish region), short interruptions are only included in the statistics when they result in complaints from customers.

Most countries use the SCADA system to measure short and transient interruptions. Local substation logging and counter readings on reclosing relays are also used.

No information was requested on aggregation rules used for counting long and short interruptions. In a parallel study, not reported in this document, large differences between European countries were observed. For short interruptions in particular this will result in significantly different values for the number of interruptions per customer.

TABLE 2.7 MONITORING AND INDICES FOR SHORT AND TRANSIENT INTERRUPTIONS IN THE DIFFERENT COUNTRIES

Country	Index	Duration of short interruptions	Measurement method
Belgium (Flemish region)	Number of complaints.	T≤3 min	-
Belgium (Federal)	AIF	T<3 min	SCADA
Denmark (3)	SAIDI and SAIFI	T≤3 min	Typically SCADA; otherwise manually
Finland	Average annual weighted frequency and duration of interruptions.	T≤3 min	Data is only available for automatic reclosings.
France	MAIFI for short interruption.	1 sec≤T<3 min	Local substation logging.
Hungary	MAIFI, weighted by number of customers; separate indices for short and transient interruptions.	1 sec<T≤3 min	SCADA
Italy	MAIFI, weighted by number of LV customers for short interruptions. MAIFItransient, weighted by number of MV customers for transient interruptions	1 sec<T≤3 min	SCADA integrated with telecontrol in MV/LV substations
Lithuania	MAIFI, weighted by number customers for short interruptions.	1 sec<T<3 min	SCADA
Norway	$SAIDI_k$; $SAIFI_k$; $CAIDI_k$; $CTAIDI_k$; $CAIFI_k$ One index covering both short and transient interruptions.	T≤3 min	SCADA, time-logging of some automatic reclosing systems, or manually.
Poland	MAIFI for short interruptions	1 sec<T≤3 min	SCADA, connectivity models and counter readings on reclosing devices.
Portugal		T≤3 min (1)	
Spain		T≤3 min (2)	
United Kingdom	SI (short interruptions): number of short interruptions per 100 customers per year.	T<3 min	SCADA or counter readings on reclosing devices.

(1) In Portugal, short interruptions are monitored and reported by the DSO but it is not obliged to do so according to the Quality of Service Code.
(2) In Spain, only short interruptions are monitored. No monitoring system is in place for transient interruptions.
(3) In Denmark, all interruptions lasting 1 minute or more are monitored.

2.4.6 Planned and unplanned interruptions

Most countries use separate indices for planned and unplanned interruptions. A planned interruption is defined in EN 50160 (the term "prearranged interruption" is used) as *an interruption for which customers are informed in advance*, to allow the execution of scheduled works on the distribution system. Most countries use this definition: advance notification is sufficient for an interruption to be classified as a planned interruption. Some more detailed descriptions are used in Poland, Belgium (Brussels Region and Flemish Region) and Portugal.

- In Belgium (Brussels and Flemish Regions), the system operator has the right, after consulting the customer, to interrupt the access to the LV, MV, or HV grid if the security, the reliability or the efficiency of the grid or the connection requires this.
- In the Czech Republic, a planned interruption is defined as an interruption necessary for planned operation, maintenance, reconstruction, revision, repair or enhancements to the transmission or distribution networks.
- In Lithuania, a planned interruption is defined as an interruption whereof the customer was informed on time and in a manner defined in legal acts or in the agreement.
- In Portugal, three reasons for planned interruptions are distinguished: interruptions for reasons of public interest; interruptions for service reasons; and interruptions for which the customer is responsible.

Whereas there is general agreement on the definition of a planned interruption; the requirement for advance notice varies strongly between countries. The requirements are summarised in Table 2.8. Some countries (Sweden and Finland) have not issued any rules. For the other countries, the advance notice requirement varies between 24 hours and the 15th day of the previous month.

Different indices that are used in order to calculate the frequency or duration experienced by the customers due to planned interruptions are reported in Table 2.9. In Belgium (Federal), planned interruptions are not monitored since they are very uncommon (mainly because all networks are meshed).

TABLE 2.8 REQUIREMENTS ON ADVANCE NOTICE FOR PLANNED INTERRUPTIONS

Country	Advance notice required
Austria	48 hours
Belgium (Brussels region)	Except in case of emergency, the system operator informs HV and MV customers at least 5 working days in advance of the start and duration of the interruption. On the LV grid, the period for announcing the interruption is 2 days. An exception is made for planned interruptions lasting less than 15 minutes.
Belgium (Flemish region)	MV, HV: 5 working days, except in case of emergency / LV: 2 working days, except in case of emergency.
Belgium (Walloon region)	TRDE art 142 and 143.
Czech Republic	15 days
Denmark	At least 48 hours notice. Notice by letter/by poster or by SMS/e-mail if the customer has accepted electronic notice. Notice hours/minutes before the interruption is accepted, if the notice is given in person (face-to-face).
Estonia	For voltage levels up to 110 kV, the system operator must inform the customer at least 7 days before the start of the interruption. Customers connected at levels above 110 kV should be informed in writing latest by the 15th day of the month preceding the start of the interruption.
Finland	No rules issued by the regulator.

TABLE 2.8 REQUIREMENTS ON ADVANCE NOTICE FOR PLANNED INTERRUPTIONS

Country	Advance notice required
France	Rules are included in the contractual commitments for the TSO. For MV customers, the DSO must agree on a date for the planned interruption at least 10 days before the interruption (except in case of emergency).
Germany	No rules issued by the regulator.
Hungary	a) Customers less than 200 kVA power must be informed 15 days before the planned interruption according to the local practice, e.g. leaflet. b) Customers above 200 kVA power must be informed 30 days before the planned interruption in a personal letter if there is no other agreement between the parties.
Italy	24 hours until 2007: From 2008: 24 hours in case of planned interruptions following a fault; 2 working days in other cases.
Lithuania	10 days. A shorter period is allowed when this has been agreed with the customer.
Luxembourg	It is foreseen by law that customers are informed as early as possible by an appropriate means of the date and time for a planned interruption. The details of the procedure may be fixed by the regulator after a public consultation.
Norway	The grid companies shall inform the affected grid customers about the timing and duration of interruptions a reasonable amount of time prior to the work commencing. The information shall be provided in an appropriate manner.
Poland	The regulator has issued rules with respect to the notice to the customers.
Portugal	Interruptions for reasons of public interest: 36 hours. Interruptions for service reasons: Agree the best moment with the affected customers. If agreement is not possible, the interruptions must occur, preferably, on Sundays, between 05:00 hours and 15:00 hours, with a maximum duration of 8 hours per interruption and 5 Sundays per year, per customer affected. The system operator must inform the customers affected with a minimum advance notice of 36 hours. Interruptions for which the customer is responsible: 8 days. If the customer installation causes disturbances to the network, the operator establishes, in accordance with the customer, a time period for solving the problem.
Romania	The advance notice should normally be given 15 days in advance. In critical conditions, but when the start of an interruption can be delayed, at least 24 hours notice is required.
Slovenia	The customer must be informed, using written form or any other suitable form, in a timely manner. If the interruption will affect a greater number of customers, the customers must be informed by public notification at least 48 hours before the start of the interruption.
Spain	24 hours.
Sweden	According to law, a “reasonable amount of pre-notice” is needed. No further rules are issued by the regulator.
United Kingdom	48 hours. A shorter advance period is allowed when this has been agreed with the customer.

TABLE 2.9 MONITORING AND INDICES FOR PLANNED INTERRUPTIONS IN THE DIFFERENT COUNTRIES

Country	Voltage levels	Indices	Details
Austria	MV and HV	ASIDI, ASIFI and ENS	
Belgium (Brussels region)	MV	SAIDI and SAIFI	
Belgium (Flemish region)	MV	CAIDI and SAIFI	
Belgium (Walloon region)	MV and LV	Frequency and duration	Estimates of frequency and duration are available per delivery point
Belgium (Federal)	All (36 kV and up)		Data is available per delivery point.

TABLE 2.9 MONITORING AND INDICES FOR PLANNED INTERRUPTIONS IN THE DIFFERENT COUNTRIES

Country	Voltage levels	Indices	Details
Denmark	All	SAIDI and SAIFI plus ENS (>100 kV)	
Estonia	LV, MV, HV	Duration	
Finland	MV, HV, T	MV T-SAIFI, MV T-SAIDI	HV and Transmission number of interruptions and interruption time for connection point for different voltage levels
France	All	Frequency and duration	
Germany	All	SAIDI and SAIFI	
Hungary	LV, MV, HV	SAIDI and SAIFI	
Italy	All	SAIDI and SAIFI	For each of the 300 districts
Lithuania	LV, MV	SAIDI and SAIFI	
Luxembourg			
Norway	Incidents above 1 kV, customers at all voltage levels	SAIDI, SAIFI, CAIDI, CTAIDI, CAIFI, ENS, interrupted power	
Poland			
Portugal	All		
Romania	LV, MV, HV	SAIDI, SAIFI	The data will be available from 2009
Slovenia	MV	SAIDI and SAIFI	
Spain	All	TIEPI, NIEPI	
Sweden	LV customers, incidents at all voltage levels		
United Kingdom	All	Frequency and duration	

2.4.7 Discussion of the different indicators

From the tables shown above, it becomes clear that a range of indicators is in use in different countries. The use of multiple indicators to quantify the continuity of supply results in more information being available and more possibilities to observe trends. The Norwegian regulator uses SAIFI, SAIDI, CAIDI, CTAIDI, CAIFI and ENS for this purpose. The Italian regulator will, from 2008, require information on the number of LV customers experiencing numbers of interruptions (i.e., the distribution of the interruption frequency for individual customers); since 2006, individual indicators on the number of interruption experienced are monitored and regulated with guaranteed standards for MV customers.

SAIFI and SAIDI are the basic indices, reported in almost all countries, albeit under different names and with different methods for weighting the interruptions. The method of weighting impacts the results and results in different biases towards different types of customers. When weighting is based on the number of customers, each customer is treated equally, independent of its size and independent of their consumption levels.

When weighting is based on interrupted power or energy not supplied, an interruption gets a higher weighting when the total interrupted power is higher. This might be because larger customers are interrupted or because the interruption takes place during a period of higher consumption. Weighting based on contracted power, rated power or annual power consumption makes the contribution of an incident during high load the same as an incident during low load.

Any weighting based on power or energy is biased towards larger customers. As larger customers typically suffer fewer and shorter interruptions, this is expected to result in somewhat lower values for frequency and duration of interruptions than weighting based on number of customers.

Weighting based on number of distribution transformers is biased towards customers served from smaller distribution transformers. As smaller transformers are typically used in rural networks, where the number of interruptions is higher, weighting based on the number of distribution transformers is expected to result in somewhat higher values for frequency and duration of interruptions than weighting based on number of customers.

Indices like ENS or END give a somewhat better indication of the consequences of an interruption than SAIFI or SAIDI. It should be kept in mind, however, that the underlying assumptions are an extreme simplification of the actual consequences of interruptions. It is not possible to exactly measure the energy not supplied, as there is no energy consumption during the interruptions.

There are several methods to estimate the amount of non-supplied energy; one may multiply the active power just before the interruption with the duration of the interruption; alternatively one may estimate the non-supplied energy from the consumption at the same time 1 day or 1 week before the interruption. An accurate estimate of the energy not supplied is made in Norway: 11 different standardised load profiles have been established for different customer categories to be used for end-users connected to 22 kV or less. Network companies are obliged to have established individual load profiles for end-users connected at 33 kV or above. Standardised load profiles are developed through research projects, while individual load profiles are based upon hourly-metered values of energy supplied over a period of more than 1 year. The calculation also uses the amount of energy supplied during the previous year to correctly adjust the standardised or individual load profile for a given year, and also takes into account measured temperature data on the time of the interruption.

In Portugal, ENS is estimated using the value of the load diagram before the interruption. For interruptions longer than 30 minutes, it uses the load diagram of the delivery point for an analogous day. The ENS is estimated when an incident in the transmission network causes an interruption for one or more customers. The ENS published is determined taking account of the period of time between the beginning of the interruption and the transmission network connection (ENS1). The TSO also takes the last period into account, plus the time that the distribution network needs to connect the clients. This time is established by the transmission network and the distribution network for each delivery point.

It should further be noted that the value of ENS depends on the annual energy consumption and cannot be used for comparison purposes when considering the actual value in MWh. However, by calculating the energy not supplied relative to the energy supplied, a comparison can be made given that the energy not supplied has been calculated using the same method.

Two of the indices used in Norway, CAIFI and CTAIDI, give a better impression of the continuity of supply as experienced by those customers that actually experience at least one interruption. The difference in value between SAIFI and CAIFI, and between SAIDI and CTAIDI, give an impression of the spread in number of interruptions between different customers. The distribution of number of interruptions experienced by each individual customer gives this information in a more direct way, but results in more indicators, making comparisons and trend analysis more complicated.

2.5 Analysis

As can be seen from Table 2.6, different countries use different indicators and different weighting methods. In this section, the values of the most important indicators are compared over a number of years. Even though different countries use different names and different calculation methods, the results are shown in the same diagrams.

The following two groups of indicators are presented: "*minutes lost per year*" (SAIDI, CML, ASIDI, T-SAIDI or TIEPI) and "*number of interruptions per year*" (SAIFI, CI, ASIFI, T-SAIFI or NIEPI). When interpreting the results and especially when comparing between countries, the differences in calculation of the indices and in the voltage levels at which incidents are monitored, should be considered.

2.5.1 Unplanned long interruptions, excluding exceptional events

The system indices ("minutes lost per year" and "number of interruptions per year") for the different countries and years are compared in Figure 2.1 and Figure 2.2. Details of the calculation of the indices are given in section 2.4. Details on the methods used for removing exceptional events are given in section 2.7. Significant care has to be taken when comparing the values between countries, as every country has its own methodology for determining what constitutes an exceptional event.

Figure 2.1 shows the minutes lost per year where interruptions due to exceptional events have been excluded from the statistics. The curves per country show a smooth trend, being in general decreasing or constant. The decreasing trend in minutes lost (i.e. improving service quality) that was visible from 1999 through 2004 (and mentioned in the previous benchmarking report) is no longer obvious. Indeed, increases in minutes lost have been observed in a few countries.

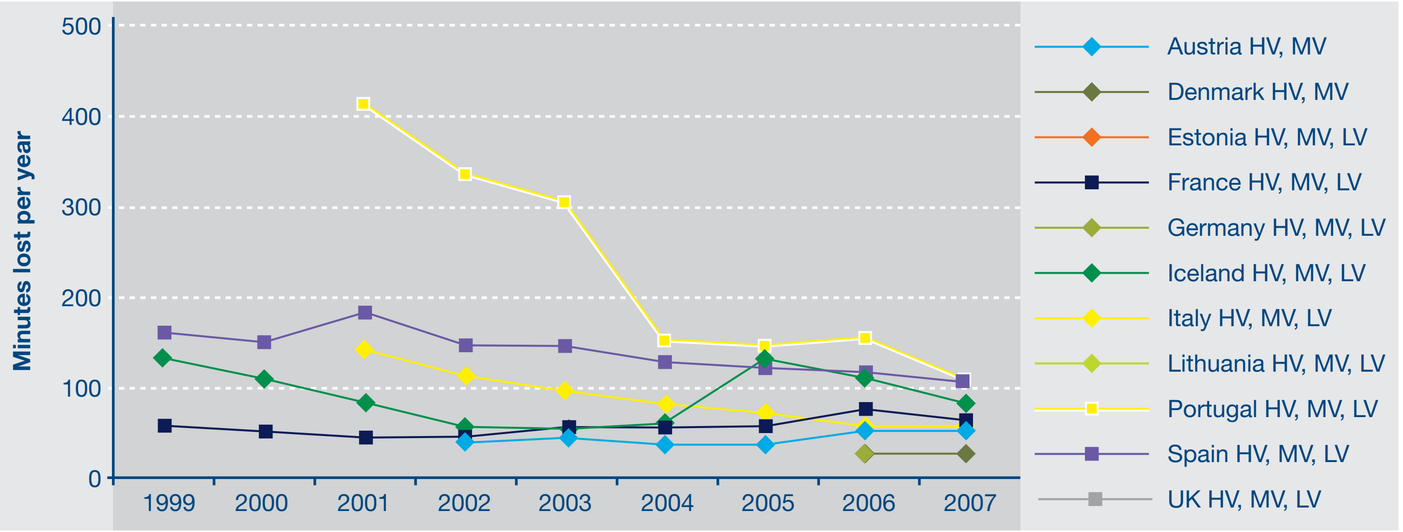
Comparing the performance between different countries is further challenged as not all countries include incidents at all voltage levels in their statistics. The values for the United Kingdom, Italy and Portugal contain interruptions for low voltage customers only, but these incidents are at all voltage levels, transmission included. Austria covers incidents at medium voltage and high-voltage only. Spain does not include transmission. In France, the report for the regulator contains statistics on the MV and LV customers concerned with unplanned interruptions that exceed 6 hours.

The improvement in the continuity of supply in Portugal has stabilised in the last 3 years and the value for minutes lost is now within the same range as for the other countries. The range in values for minutes lost among the countries that provided data is between 50 and 150 minutes per year. Keeping in mind the large differences in data gathering, in calculation of indices and in the definition of exceptional events, this range is not very large.

Figure 2.2 shows the number of interruptions per year, where interruptions due to exceptional events have been excluded from the statistics. This indicator shows the same trends as for minutes lost in the previous figure.

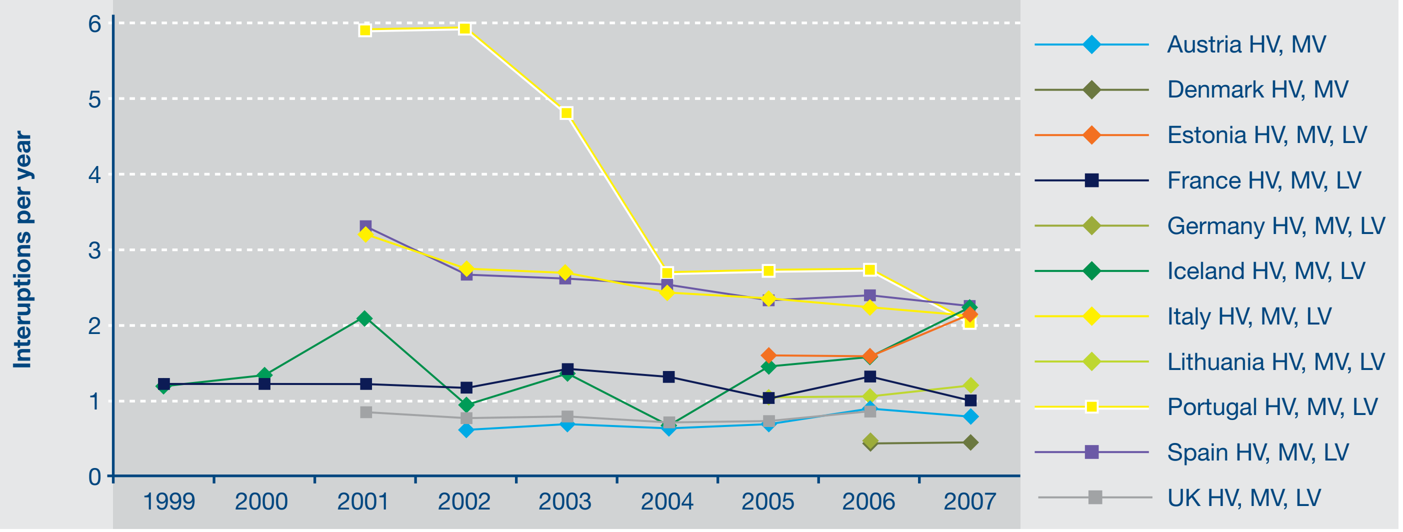
The improvement in continuity of supply for Portugal has continued also for the number of interruptions, giving Portugal a value within the same range as the other countries. The range in values for number of interruptions among the countries that contributed data is between 0.5 and 2.5. This range is somewhat larger than for minutes lost (a factor of 5 versus a factor of 3), but still reasonably small considering the various differences discussed before.

FIGURE 2.1 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; MINUTES LOST PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

FIGURE 2.2 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

To be able to better analyse the trends, the average and standard deviation have been calculated for each of the years over all reporting countries. The results are shown in Figure 2.3 and Figure 2.4. The middle curve represents the non-weighted average over all reporting countries. The upper and lower curves represent average plus or minus one standard deviation. The values for Portugal have been removed from the analysis, as the improvement obtained in that country would dominate the result. The trends in both minutes lost and in number of interruptions are clearly visible for Portugal from the above figures. Before 2001, values for number of interruptions were only available for 2 countries; values before 2001 have therefore been removed in Figure 2.4. The trend in minutes lost per year continues to show an almost continuous decreasing trend, whereas the average number of interruption per year seems to be somehow constant since 2002. Both figures show a reduction in the standard deviation during the last years that can be the interpreted as a rapprochement of the continuity level in European countries, especially regarding the minutes lost per year.

FIGURE 2.3 TRENDS IN MINUTES LOST PER YEAR EXCLUDING EXCEPTIONAL EVENTS: NON-WEIGHTED AVERAGE AND STANDARD DEVIATIONS OVER ALL REPORTING COUNTRIES, EXCLUDING PORTUGAL

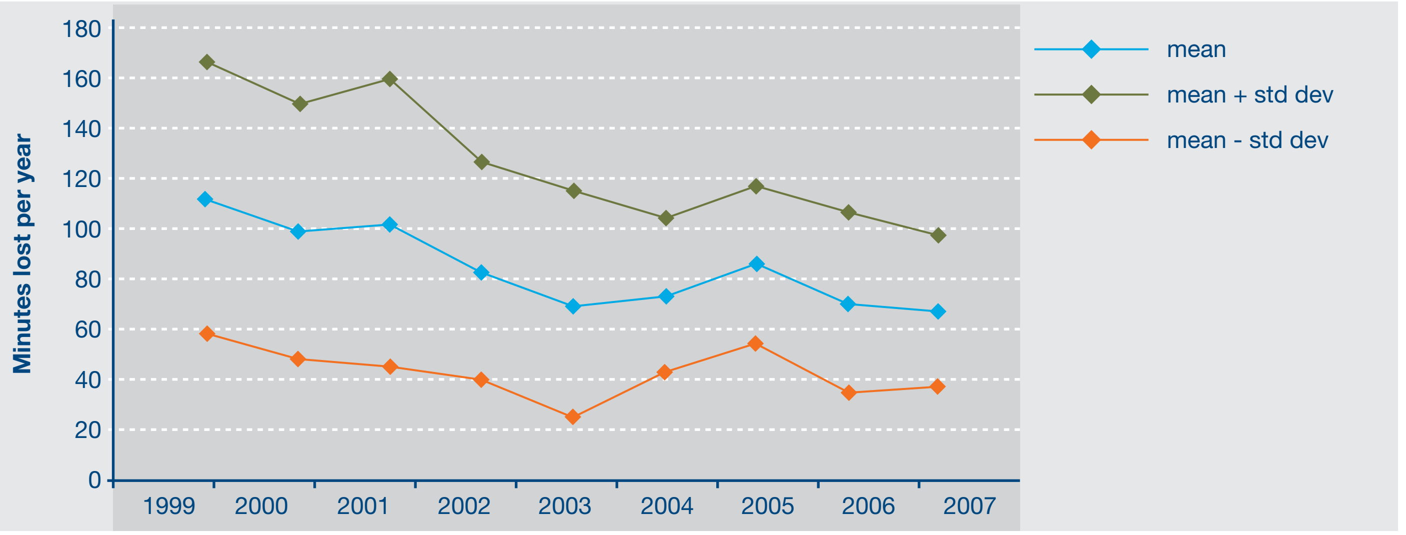
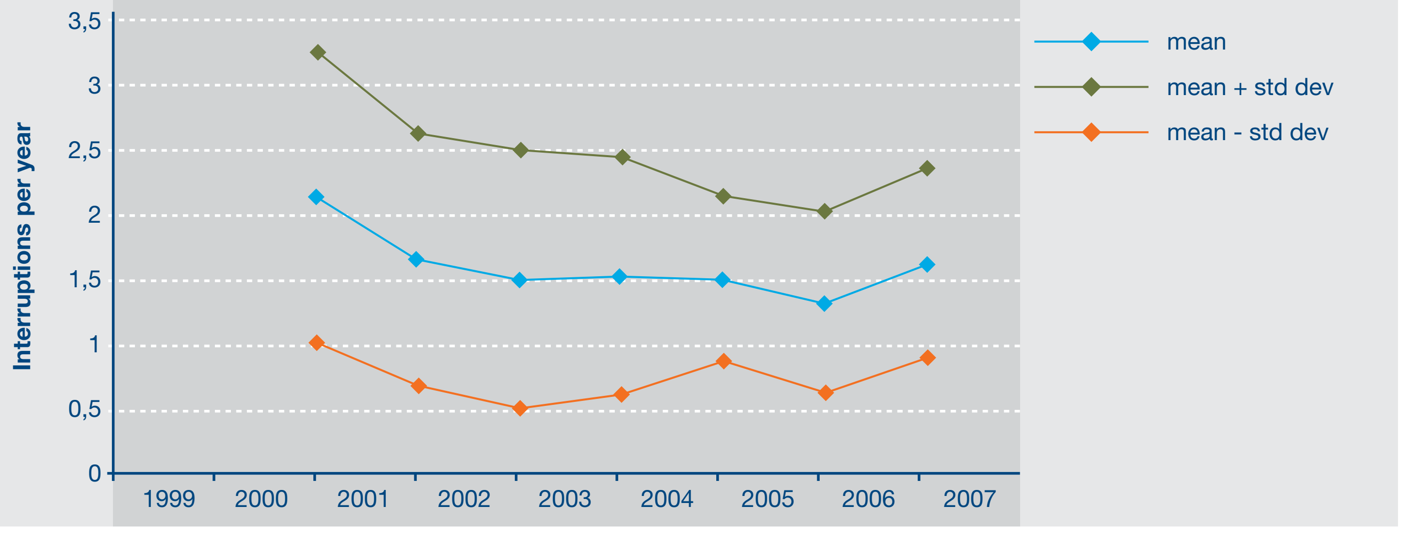


FIGURE 2.4 TRENDS IN NUMBER OF INTERRUPTIONS PER YEAR EXCLUDING EXCEPTIONAL EVENTS: NON-WEIGHTED AVERAGE AND STANDARD DEVIATIONS OVER ALL REPORTING COUNTRIES, EXCLUDING PORTUGAL

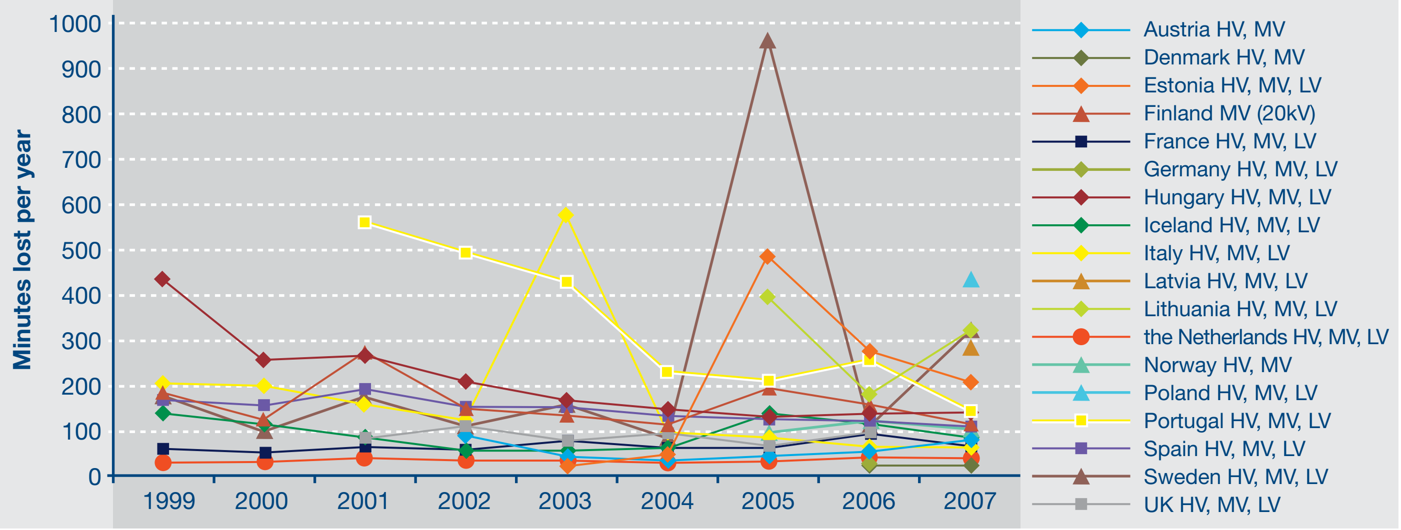


2.5.2 Unplanned long interruptions, all events

Data was also obtained about the continuity of supply indicators including all events, i.e., without removing exceptional events from the statistics. Figure 2.5 shows the minutes lost per customer per year, with all interruptions included in the statistics. The values show much larger year-to-year variations than the filtered values in Figure 2.1. The blackout on 28 September 2003 and the load shedding on 26 June 2003 caused the high value for minutes lost in Italy. Finland shows a high value for minutes lost in 2001 (due to autumn storms) as does Hungary in 1999. The high value for Sweden in 2005 is due to a severe storm that resulted in extremely long interruptions in the southern parts of the country.

If we remove the values for Portugal before 2004 and the high values for Hungary in 1999, Finland in 2001, Italy in 2003 and Sweden 2005, the range of values for minutes lost over the countries that contributed with data ranges between 50 and 250 minutes per year.

FIGURE 2.5 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; MINUTES LOST PER YEAR (1999 - 2007)

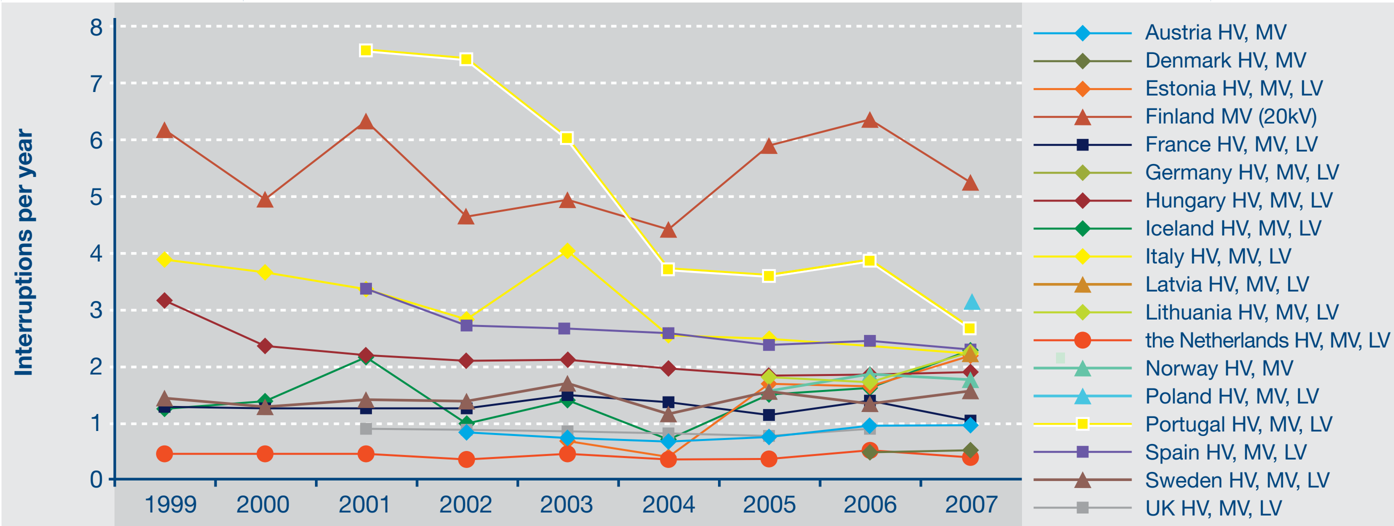


The voltage level (LV, MV, HV) is related to where the incidents occur.

Figure 2.6 shows the number of interruptions per year, with all interruptions included in the statistics. The year-to-year variation in the number of interruptions is less than for minutes lost: extreme events result in longer interruptions more often than in more interruptions. The number of interruptions for 2003 in Italy is about 1 interruption higher than the value for neighbouring years (because the 28 September blackout affected almost all Italian customers); the minutes lost are, however, 450 minutes higher than in neighbouring years. The exception is 2001 in Finland, where the number of interruptions is 3.5 interruptions more than in 2000 or 2002; the minutes lost are about 350 minutes higher than in 2000.

If we remove the values for Portugal before 2004 and the high values for Finland in 2001, 2005 and 2006, the range of number of interruptions over the countries that contributed data is between 0.5 and 4 interruptions per year.

FIGURE 2.6 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

2.5.3 Planned interruptions

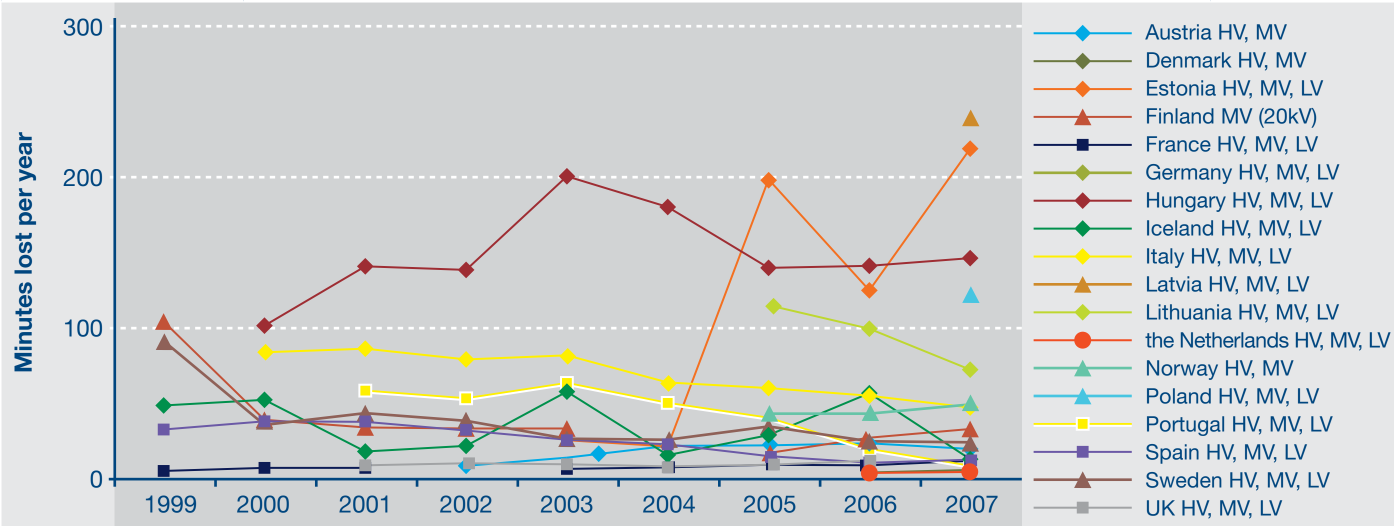
The minutes lost per year due to planned interruptions, for the reporting countries, are presented in Figure 2.7. The value shows a very wide spread between the countries, between less than 10 minutes per year and 200 minutes per year. No trends are visible in the figure; the minutes lost due to planned interruptions remain more or less the same during the observation period, although some countries show a minor reduction.

The differences between countries may be due to the way in which the distribution network is designed (with or without redundant supply paths) and the amount of maintenance and building in the distribution network. A temporary high level of planned interruptions could be a sign of investments in the distribution networks, aiming at reducing the number of unplanned interruptions in the future. High levels of planned interruptions can also be due to replacement and repair of components that were provisionally restored after a major storm and due to a widespread replacement of energy meters.

Not all countries include interruptions due to planned maintenance at low voltage in the statistics. Radial networks without redundancy, where planned interruptions are necessary for maintenance, are more common at low-voltage levels. Not including incidents at low voltage may significantly underestimate the number and duration of planned interruptions. Incidents at LV are not included in the values for Austria, Finland and Norway.

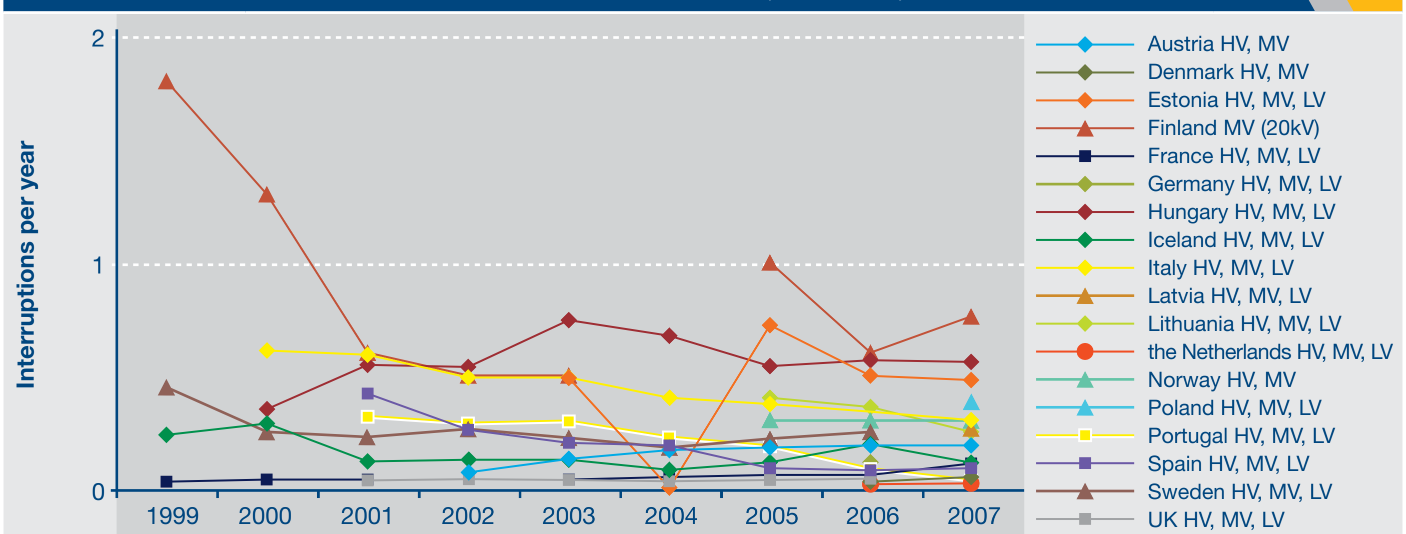
The number of planned interruptions per year is shown in Figure 2.8. Like minutes lost, the number of interruptions also varies significantly between countries and there is no clear trend visible. Note that Portugal has shown a reduction in both planned and unplanned interruptions.

FIGURE 2.7 PLANNED INTERRUPTIONS:
MINUTES LOST PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur. The French values in the figure are lower than the reality.

FIGURE 2.8 PLANNED INTERRUPTIONS:
NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

2.5.4 Comparison of rural and urban networks

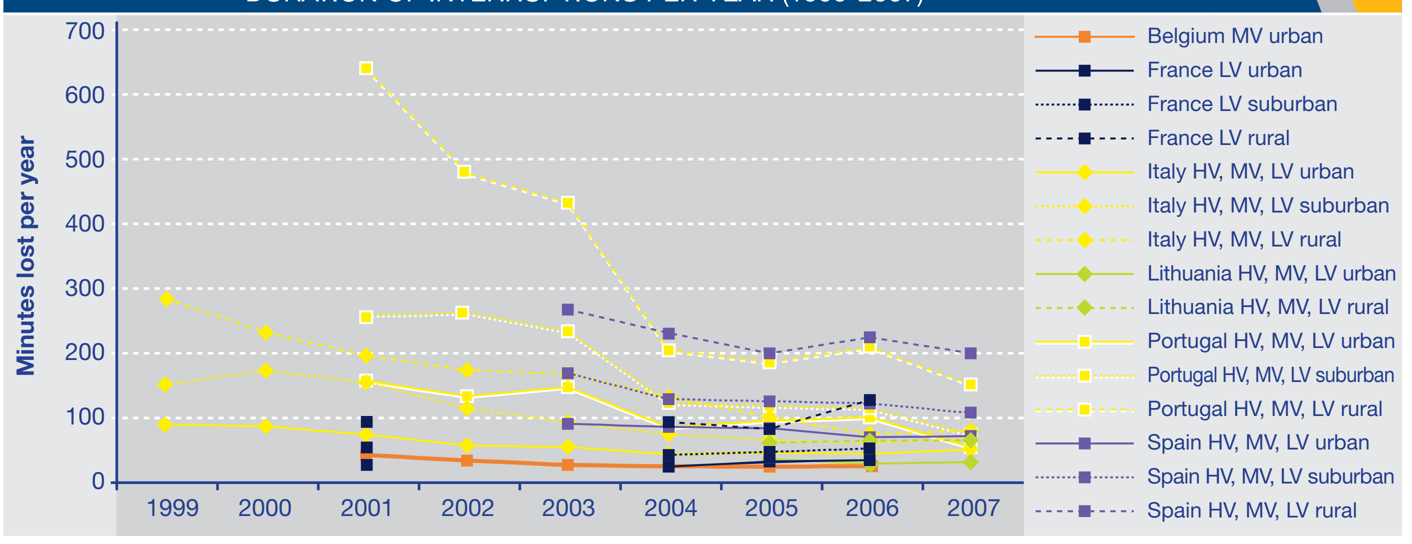
In some countries, a comparison is made between the continuity of supply in rural, suburban and urban networks. Data was available for 6 countries, Belgium, France, Italy, Lithuania, Portugal and Spain as shown in Figure 2.9 for duration of interruptions and in Figure 2.10 for the numbers of interruptions.

The overall conclusion is that the continuity of supply improves when moving from rural to suburban to urban areas. The values for the numbers of interruptions for the three areas are similar in Spain and Italy. The values for the duration of interruptions are however systematically higher in Spain than in Italy. Improvements in continuity of supply have taken place in Italy in all areas, but most in the urban and suburban areas. The difference in number and duration of interruptions between the areas has decreased during the years.

TABLE 2.10 DEFINITIONS OF URBAN, SUBURBAN AND RURAL AREAS IN USE IN 6 EUROPEAN COUNTRIES

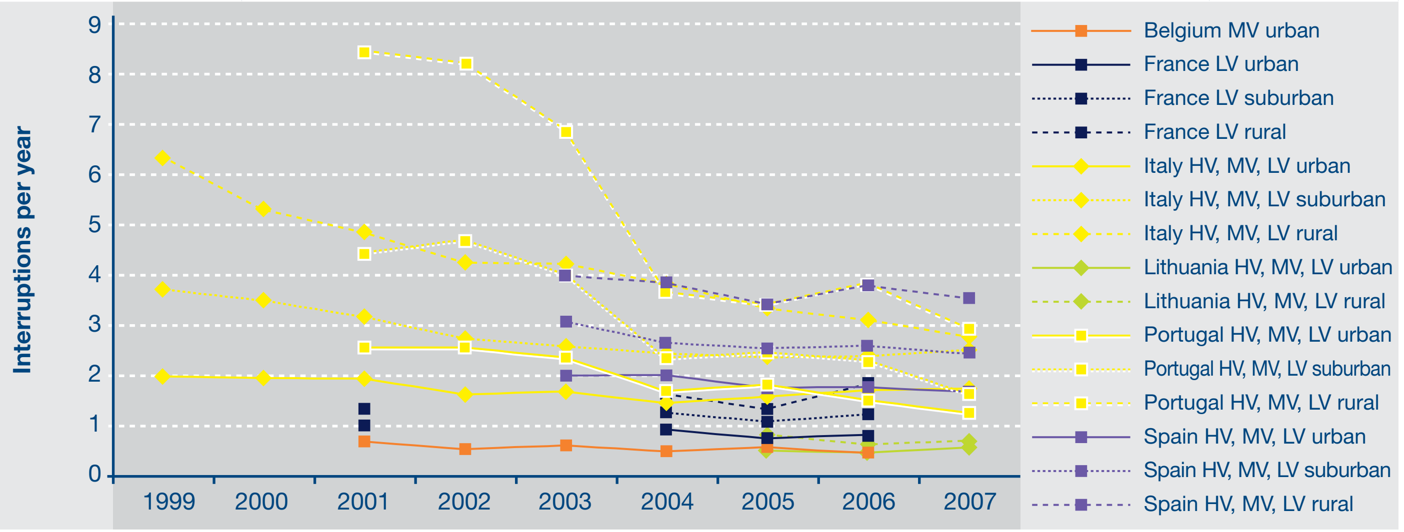
Country	Areas	Definitions
Belgium	urban	Brussels region
France	urban	towns with more than 100,000 inhabitants and Paris area
	suburban	towns and surroundings with more than 10,000 inhabitants
	rural	towns and villages with less than 10,000 inhabitants
Italy	urban	municipalities with more than 50,000 inhabitants
	suburban	municipalities with less than 50,000 and more than 5,000 inhabitants
	rural	municipalities with less than 5,000 inhabitants
Lithuania	urban	cities, small towns and all compact settlements that have more than 500 inhabitants or have described indication (according to the Law) of small town or township
	rural	all other areas, which can not be attributed to urban
Portugal	urban	Zone A: (2001-2002) locality with more than 25,000 of clients / (since 2003) main cities and localities with more than 25,000 of clients
	suburban	Zone B: (2001-2002) locality with less than 25,000 and more than 5,000 of clients / (since 2003) locality with less than 25,000 and more than 2,500 of clients
	rural	Zone C: (2001-2002) locality with less than 5,000 of clients (since 2003) locality with less than 2,500 of clients
Spain	urban	Supplies > 20,000 (capital cities included)
	suburban	2,000 < Supplies < 20,000
	rural	Supplies < 2,000

FIGURE 2.9 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; DURATION OF INTERRUPTIONS PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

FIGURE 2.10 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; NUMBERS OF INTERRUPTIONS PER YEAR (1999-2007)



The voltage level (LV, MV, HV) is related to where the incidents occur.

2.6 On-Site Audits on Continuity Data

In this section, only on-site audits are included, it is however expected that all regulators carry out desk-top audits in order to assure the most correct data for the statistics of continuity of supply as possible.

As reported in Table 2.11, less than half of the surveyed countries regularly conduct on-site audits on continuity data provided by the companies; namely Hungary, Italy, Lithuania, the Netherlands, Norway, United Kingdom, Portugal, and Spain. 3 countries are interested in implementing audit procedures in the near future; namely Finland, Romania and Sweden. In addition, an audit was performed by an external auditor in Belgium Flemish region in 2006.

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).

TABLE 2.11 ON-SITE AUDITS ON CONTINUITY DATA

Auditing authority	Country
By the regulator	HU, IT, LT, NL, NO
By consultants on behalf of the regulator	UK
By consultants on behalf of the companies (results are submitted to the regulator, and if necessary the regulators can do an inspection)	ES, PT
Under consideration	FI, (from 2009) RO (from 2008), SE (from 2008)
No on-site audits	AT, BE, CZ, DE, DK, EE, FR, LU, PO, SI

Carrying out on-site audits can vary significantly across the surveyed countries, as reported in Table 2.12.

- Most of the countries perform annual audits (IT, LT, NO, UK and ES). In Hungary, it is performed twice per year; the first audit is for the recorded data and the second audit is for the recording procedure. In Portugal and the Netherlands, the audit is performed biennially.
- Generally, both the recorded data and the recording procedure are audited for most countries (HU, IT, LT, NL and UK). The recorded data that is audited also varies. In Italy long and short interruptions, in particular the unplanned ones, are audited. In Spain incidents, index calculations, and informational systems are audited. In Portugal, the recording procedure and criterion used to determine the quality of continuity indicators are audited. In Hungary, planned and unplanned interruptions are audited from the point of view of the start and end of interruptions and the customers affected. In Norway, the requirements in the regulations concerning quality of supply (including continuity of supply) and how the companies comply with them are audited. In the United Kingdom, long interruptions and data accuracy of reporting short interruptions are audited.
- Generally, there is a roadmap to follow when auditing the companies (HU, IT, NO, UK, and ES). In Spain, the roadmap is specified in Order ECO/797/2002. In Hungary, the Hungarian Energy Office has published a roadmap for audits. The auditing procedures are different from one country to another. In Italy, a checklist is sent to the distribution companies to be inspected some days in advance of the audit. Through this checklist, the companies declare their adopted procedures for the registration of the interruption. In the United Kingdom, the auditing company, Ofgem, informs the distribution companies in advance of what indices will be audited.
- Generally, the audits result in fines in the cases of non-compliance with the roadmap.

TABLE 2.12 AUDITING PRACTICES

Country	How often	What is audited	Road map	On-site audited companies (of total companies)	Audit's result/effect
Hungary	Biannually	Recorded data and recording procedure	Yes	100% (of 6)	Fine for wrong data at repeated audits
Italy	Annually	Recorded data and recording procedure. On- site audit.	Yes	15% - 25% (of around 300 districts)	Validate continuity data and penalty in case of inadequate recording
Lithuania	Annually	Recorded data and recording procedure.	No	100% (of 4)	Validate continuity data. From 2008, penalty in case of inadequate recording
the Netherlands	Biennally	Recorded data and recording procedure.	Yes	100% (of 10)	Non-compliance with the Ministerial Regulation on Quality Aspects of Network Operation Electricity and Gas is reported to the Minister of Economic Affairs and can result in a penalty.

TABLE 2.12 AUDITING PRACTICES

Country	How often	What is audited	Road map	On-site audited companies (of total companies)	Audit's result/effect
Norway	Annually	Recording and reporting procedures.	Yes	10 audits annually (of a total of 135 companies)	Non-compliance with the regulation on quality of supply in the power system will result in an individual decision by the regulator. If the negative results are not rectified within a given time limit (e.g., change of procedures), compulsory fines (running) can be issued (e.g., daily) until the negative results have been rectified. A violation fine for having breached the regulations can also be issued.
United Kingdom	Annually	Recorded data and recording procedure. On-site audit.	Yes	100% (of 14 license areas)	Penalty for failure to meet the minimum data accuracy level.
Portugal (1)	Biennially	The systems and the procedures.	No	15% (of 13)	NA(1)
Spain	Annually	The systems and the procedures.	Yes	100% (of 320)	Penalty in case of non-compliance with order ECO/797/2002 (the road book)

(1) In Portugal mainland there are one TSO, one HV and MV DSO, and 11 LV DSO. The main distribution company in LV distributes 99.5% of the electrical energy. The audits are carried out by the TSO, the HV and MV DSO and the main LV DSO.

2.7 Exceptional Events

As explained in section 2.1.6; exceptional weather conditions and other exceptional circumstances can affect the continuity of supply. Interruptions due to exceptional events can be very long, even if they are quite rare. This section contains information on existing definitions and, where available, regulations in use in various European countries regarding the concept of "exceptional events". The term "exceptional events" will be used as a collective term in this section; including several different "exceptional" situations. The different kinds of exceptional events in use, their definition, the entity that classifies situations as exceptional events, whether exceptional events are visible in the interruption statistics and whether they are excluded from any compensation payment are presented for different countries. The information collected from the CEER member countries shows, however, that there is no harmonisation in place, and perhaps harmonisation is neither feasible nor envisaged, because of the inherent differences in climate among European countries. The lack of harmonisation as regards exceptional events will, however, affect the comparison of interruption data between various countries. As it was not possible to neutralise the consequences of these differences between countries, it was considered important to analyse and report how exceptional events are considered in the interruption statistics of each country. Also, some practices taken at national level in order to minimise the effects of exceptional events and to protect customers under these special circumstances are reported.

In Table 2.13, the definitions of different kinds of exceptional events for the various countries are presented, the entity that classifies situations as exceptional events, whether exceptional events are visible in the interruption statistics and whether they are excluded from compensation payments.

TABLE 2.13	DIFFERENT KINDS OF EXCEPTIONAL EVENTS IN VARIOUS EUROPEAN COUNTRIES				
Country	**Designation**	**Concept**	**Who classifies the exceptional events?**	**Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?**	**Are exceptional events excluded from compensations payment?**
Austria	Natural disaster	Natural disaster takes place if a crisis situation is declared by a local authority and/or if the federal or provincial government takes measures aimed at providing financial support (e.g. catastrophe funds). In these cases it is necessary to give detailed descriptions of the natural disaster for the failure and disturbances statistics of electricity networks.	Local authority (crisis management group) such as the mayor and/ or if the federal or provincial government takes measures aimed at providing financial support (e.g. catastrophe funds).	Yes. Continuity of supply indicators are published without exceptional events. In addition the value of the indicator for exceptional events is published.	There are no compensation payments in Austria.
Belgium (Brussels region)	Force Majeure Emergency situations as a result of a force majeure				
Belgium (Flemish region)	Force Majeure Emergency situations as a result of a force majeure				

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Belgium (Walloon region)	Force Majeure	The emergency situations justifying the intervention of the system operator, can occur, among others, in following unforeseen or extraordinary situations: 1.° natural disasters, 2.° a nuclear or chemical explosion and their impact; 3.° a computer virus, computer crash for reasons other than old age or the lack of maintenance of this system, 4.° the temporary or continuing technical inability for the grid to exchange electricity because of disturbances within the control area caused by electricity flows which are the result of energy exchanges within another control area or between two or several other control areas and of which the identity of the market participants involved at these energy exchanges is not known and cannot reasonably be known by the system operator, 5.° inability to use the system because of a collective dispute, giving rise to a unilateral measure of the employees (or groups of employees) or each other labour dispute, 6.° fire, explosion, sabotage, terrorist actions, actions of vandalism, damage by criminal actions, criminal coercion and threats of the same nature, 7.° a state of war, declared or not, a war threat, an invasion, an armed conflict, blockade, revolution or insurrection, 8.° ”fait du prince” (action by government unhampered by legal considerations).	The Government (in some cases the NRA lists events that are classified as exceptional).	Yes. SAIDI is calculated with and without exceptional events at DSO level.	

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Belgium (Federal)	Force majeure	It is a Civil law concept but as such has no specific regulatory definition. The Access contract defines force majeure as follows: all reasonably unforeseeable situations, occurring after the conclusion of this contract and not caused by one of the parties, which make the implementation of the contract temporarily, or definitively, impossible. Situations of force majeure are, amongst others, the emergency situations as defined in the grid code.	The parties to the regulated contract	No	Yes. In case of emergency situation or force majeure, the performance of the contractual obligations is suspended.
Czech Republic	The concept of exceptional event does not exist.				
Denmark	Exceptional event	Hurricanes and floods. The concept is established in § 20 in Executive order 1520 of December 23, 2004 concerning income cap. The Regulators guide for monitoring interruptions for distribution and regional transmission companies (3rd edition, March 2008).	The regulator.	Yes	There are no automatic compensation payments in Denmark.
Estonia	Exceptional event	When interruptions are caused by events of long duration (e.g.: natural disaster, heavy winds or glazed frost that exceeds design norm, war).		Yes	Yes. Company has to pay compensation only in cases where the interruption time that exceeds the limits does not include exceptional events.

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Finland	The concept of exceptional event does not exist.				No. Compensation due to interruptions exceeding 12 hours apply for all interruptions, irrespective of the cause.
France	Exceptional event	Breadth of occurrence (simultaneous interruption for more than 100,000 end-users) Occurrence probability of this kind of climatic event on the concerned area (less than 1 / 20 years), according to meteorological data.	TSO and DSO	Yes. Continuity of supply indicators are published with and without exceptional events.	Yes. Contractual commitments of TSO exclude “force majeure” events, so there is no compensation for damage occurring from these events. No. But there is a tariff rule concerning very long interruptions (duration > 6 hours), with a 2% tariff discount applied on the fixed part of the tariff for each 6-hour period.

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Germany	Force majeure	In rulings from the highest court, force majeure is construed as an event brought about externally, as a result of elemental natural forces or an action by a third party, which cannot be foreseen using sensible standards of judgment, which cannot be prevented or rendered harmless with economically reasonable means even with the utmost care that could reasonably be expected in the circumstances, and which also cannot be regarded as acceptable for the operating company on the grounds of frequency. (BGHZ 7, 338, 339; BGH, Urteil vom 15. November 1966 - VI ZR 280/64 - VersR 1967, 138, 139 m.w.N., BGH, Urteil vom 15. März 1988, Az: VI ZR 115/87). Force majeure includes, but is not limited to, natural disasters of an exceptional nature, strikes, legal and official orders, terrorist attacks and war.	Jurisdiction, NRA In case a DSO claims an outage is due to force majeure the DSO needs to give more details on the event. The NRA verifies it ex post.	Yes. The German Regulator calculates the continuity of supply indicators with and without exceptional events.	There are no compensation payments in Germany.
Hungary	Exceptional event	System continuity indicators: system collapse, terror attacks and “other event” classified by the NRA. Guarantees standards: Outage of 50,000 customers if the designed criterion is fulfilled by DSO.	DSO according to the rules, except for system continuity indicators: in the case of ”other event” it is classified by NRA	Yes. There is a 3-year averaging of all interruptions, set by the regulation. Therefore, report includes all events for the preceding calendar year plus a 3-year rolling average of all such events. Upon claim from the DSO subsequent to an exceptional event the regulator may (i.e. if pre-set criteria are met) grant an exemption.	Yes. Events are excluded if interruptions affected more than 50,000 customers and the designed criteria are fulfilled by DSO.

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Italy	Exceptional condition periods	Based on a statistical exploration of the distribution companies records of the single electrical service faults. According to this analysis, a simple computational algorithm identifies for the reference year the exceptionality threshold as a function of the average number of faults in a 6-hour time interval as observed in the three year time period preceding the reference year.	It's up to the DSO to apply the rules and the statistical algorithm set by the NRA. The NRA does not approve each single exceptional event but can conduct ex-post audits.	Yes. Both series of data are published.	Yes as a general rule, but compensation payments for very long interruptions are envisaged even when exceptional events occur.
Luxembourg	Force majeure	Common understanding for force majeure: All normally unforeseeable events which are external to the party invoking it, and which can't be surmounted by the deployment of reasonable efforts to which this party is bound. There are no predefined events which would always be considered as force majeure.	Jurisdiction, NRA (via approval of contracts)	Not yet.	There are no automatic compensation payments in Luxembourg.
the Netherlands	Force majeure (or extreme situation)	Incidents which occur so infrequently that it would be uneconomical to take these into account in the regulatory system and which are also beyond the control of the grid manager (e.g., powerful earthquakes, major floods, wars). This usually relates to incidents which cause exceptional and/or extensive damage to the facility, which affect a substantial number of consumers and the repairing of which takes significantly longer than usual.	TSO or DSO has to prove force majeure based on applicable legal opinion	No. But exceptional events are excluded from SAIDI for calculating the q-factor in quality regulation.	Yes.
	Highly critical power situations	Load shedding to preserve system integrity in case of severe supply-and-demand imbalance.	NRA via System Code		

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Norway	Extraordinary situations	Defined in each individual case	TSO and DSO	No. Indicators are reported including all interruptions, even if interruptions are due to incidents categorised as extraordinary situations or highly critical power situations.	Not in general. But the companies are able to apply to the regulator for an exception in each individual case.
	Highly critical power situations	Normally related to tight energy balance situation	NRA based on advice from the TSO		
Poland	Force majeure	The sudden event, unpredictable and independent from will of the parties, which makes it impossible to meet contractual obligations, wholly or partly, permanently or temporarily and whose effects cannot be anticipated, even with the due care of the parties. The manifestations of the force majeure are in particular: natural disasters, including fire, flood, drought, earthquake, hurricane, hoar frost, the acts of state, including martial law, emergency state, embargoes, blockades, etc. acts of war, the acts of sabotage, acts of terrorism, general strikes or other social unrests, including public demonstrations, lock-outs. The above definition is given in the Transmission Grid Code.	TSO and DSO. The customer can appeal the decision to the NRA.	Not yet. Continuity of supply indicators will be reported both including and excluding interruptions due to exceptional events beginning in 2009.	Yes

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Portugal	Force majeure	At the same time unpredictable, irresistible and external to the network.	TSO and DSO. For Portuguese mainland, every interruption with END greater than 50 MWh must be reported to NRA. For the archipelagos, the END limits differ from island to island.	Yes. The TSO and the DSO publish the indicators determined with and without exceptional events.	Yes. All interruptions caused by the following are excluded: - fortuitous reasons or - force majeure", - public interest, - service reasons, - safety reasons, - agreements with the client, - facts attributable to the customer.
	Security situations	The supply must be interrupted because it may be a danger to the safety of people and goods.			
Romania	Force majeure	Incidents, beyond the control of the parties, and certified by competent authority in accordance with the law, such as strikes, wars, embargo, revolutions, earthquakes, fires, floods or other natural disasters.	It must be confirmed by the Chamber of Commerce, Industry and Agriculture	Yes. Continuity of supply indicators are published with and without exceptional events.	Yes.
Slovenia	Force majeure	More severe than the network requirements.	NRA	Not yet, however, the data will be published starting with 2008 in terms of indicators SAIDI/SAIFI.	There are no compensation payments in Slovenia.
Spain	Force majeure	Incidents accepted by competent administration or decided by Regional government or national government decisions or Civil Protection Service decisions and also all extraordinary atmospheric phenomena (not statistically common) which exceed limits established in Royal Decree 300/2004. An incident cannot be classified as force majeure if it can be considered normal in a certain geographical area, according to available statistical data.	Competent administration or decided by Regional government or national government decisions or Civil Protection Service	Yes. Both series of data are published (including and excluding interruption out of the control of distribution companies it is subdivided by force majeure and third part causes).	Yes

Country	Designation	Concept	Who classifies the exceptional events?	Are continuity of supply indicators reported both including and not-including interruptions due to exceptional events?	Are exceptional events excluded from compensations payment?
Sweden	Exceptional event	Events outside the DSO's control. This does not apply for nominal voltage levels above 220 kV.	System operator. The customers can appeal the decision on court.	No. Exceptional events are included in the statistics.	Yes. Customers are automatically compensated if the interruption is within the DSO's control. Apply to voltage up to and excluding 220 kV.
United Kingdom	Exceptional event	Weather related - as a fault that results in more than eight times the daily average fault rate on higher voltages Non-Weather related - events outside of the DSOs control that result in more than 25,000 customers interrupted and/or 2 million customer - minutes lost	The NRA classifies events as exceptional. The system operators must file a claim for the event to be considered as such.	Yes. Indicators are published including and excluding exceptional events.	Some situations. Exceptional events are quantified. The interruptions excluded from the compen-sations are by cause.

2.7.1 The concept of exceptional events

The concept of exceptional events is widely used all over Europe, but it is used for classifying very different situations. According to the responses received from 20 countries; the Czech Republic and Finland are the only 2 countries which do not consider the concept of exceptional events or other similar concepts related to situations having a specific treatment in their national quality of supply regulations. For the other 18 countries answering the questionnaire, the concepts of different kinds of exceptional events are defined as described in Table 2.13 and can be grouped as follows:

- Exceptional events/ Extraordinary situations;
- Force majeure;
- Emergency situations;
- Multiple incident situations;
- Security situations;
- Highly critical power situations.

The answers received indicate that countries using the designation of force majeure employ it not only for quality of supply regulation application but also, in a more general way, in civil law. These situations can be classified based on their causes or on their impact on network performance.

The causes of the incidents identified by the different countries as justifying a specific treatment in quality of supply regulation are described in Table 2.13 and can be summed up as the following:

- System collapse, terror attacks and “other events” classified by the national regulatory authorities (NRA), for system continuity indicators purpose;
- At the same time, being unpredictable, irresistible and external to the network;
- Generation inadequacy;
- Strikes with external causes;

- Natural disaster;
- Incidental and uncontrollable 3rd party damages (fire, explosion, plane crash...);
- Voluntary destructions (war, riots, terrorism...), order by public authority (for instance for safety reasons);
- More severe conditions than the ones considered at the network design requirements;
- Emergency situations justifying the system operator intervention, occurring among others in follow-up of unforeseen or extraordinary situations;
- Events where the supply has to be interrupted for safety reasons.

It is noted that the above referenced situations are generally classified as force majeure. However, the definition of exceptional events is often related to the impact on network performance. For example, the responses received indicated that an exceptional event takes place due to:

- Breadth of the occurrance (simultaneous interruption for more than 100,000 end-users);
- Occurrence probability of a certain kind of climatic event in the concerned area (less than 1/20 years), according to meteorological data. (This kind of approach requires the availability of a database with statistical information on climate events).

In Estonia, Hungary, Italy and the United Kingdom, the classification of an exceptional event considers both the cause and the impact on network performance.

- In Estonia, an exceptional event is declared as an interruption caused by events of a long duration (example: natural disaster, heavy winds or glazed frost that exceeds design norm, war) that could not be foreseen (prevented) by the network operator. The interruption must be eliminated within 3 days after the end of the event.
- In Hungary, for the application of the minimum guaranteed standards, the classification of an exceptional event is used for an interruption of more than 50,000 customers, if the guaranteed standards are fulfilled by the DSO.
- In Italy, exceptional events are identified when the number of faults on MV networks or LV networks over the course of 6-hours exceeds a function of the historical average number of faults in a 6-hour time period as observed in the prior 3 years.
- In the United Kingdom, the exceptional events are split into two different categories: weather-related and non-weather related.
  - Severe weather exceptional events are defined as the ones resulting in a fault of more than eight times the daily average fault rate on higher voltages.
  - Non-weather exceptional events are defined as events outside the DSO's control that results in more than 25,000 customers interrupted and/or 2 million customer-minutes lost.

In Norway, two different terms exist - extraordinary situations and highly critical power situations. Extraordinary situations are defined in each individual case, i.e., a single definition does not exist. Highly critical power situations are normally related to tight energy balance situations.

Table 2.13 summarises, inter alia, the different terms used in various countries, their definitions and the entity that classifies them. This table shows the wide differences on the classification of various kinds of exceptional events that are given specific treatment in quality of supply regulation. These terms are dependent on country-specific environmental characteristics, weather conditions, network characteristics and the characteristics of the electricity generation plants within the countries.

The classification of an incident as an exceptional event is of utmost importance when studying continuity of supply data if exceptional events are visible in the statistics. Whether exceptional events are included or excluded from the interruption statistics varies between the various countries.

Generally, the classification of events is done by the TSO/DSOs or by the NRA. However, due to the nature of these events and the existing information asymmetry between the system operators and the NRA, a direct or an indirect intervention of other entities to clarify or state the exceptional nature of each one of the events is necessary.

Also, there is the assumption that the system operator is responsible for network management, which means that the system operator is usually the entity that must justify the classification of each event.

The evolution of the force majeure concept in Italy, described in Additional information A 2.1 below, sets out the difficulties related to this concept definition in practice and how a statistical approach to the classification of exceptional events is justified by the simplification of the quality of supply regulation.

Additional information A 2.1 - The evolution of the exceptional event concept in Italy

As regards continuity of supply regulation, in the first regulatory period (2000-2003), a *force majeure* event was declared when a natural disaster or severe weather condition occurred and only if network design requirements were exceeded. The DSO had to justify the exceptional nature of the event classified as "force majeure", collecting written technical or administrative evidence. For instance, when a DSO wanted to attribute the classification of a *force majeure* event to an interruption, a formal declaration of calamity given by the government or wind speed measurements made by an independent weather centre, or other credible evidence had to be presented to the regulatory authority for inspection.

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 addition, a few controversial cases, where the exceptional nature of the event was claimed by the companies, but could not be formally proven, generated various disputes.

In 2003, for the second regulatory period (2004-2007) and in order to simplify the "documentation" procedure, AEEG introduced a statistical method to define "major event days" and distribution companies could choose to apply this 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 that opted for the EPR statistical method could not invoke the application of *force majeure* classification even if they could collect written evidence of the situation.

For the third regulatory period (2008-2011), AEEG developed a new statistical methodology for the identification of exceptional events. The new methodology for the identification of "exceptional condition periods" 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.

For MV faults, the exceptionality threshold is equal to 2.3+9.4**avgMV*, where *avgMV* is the historical average value of number of MV faults calculated as explained above.
For LV faults, the exceptionality threshold is equal to 3.5+7.1**avgLV*, where *avgLV* is the historical average value of number of LV faults calculated as explained above.

The exceptionality test is applied separately for LV and MV voltage levels, for each province, for provinces where more than one distribution company operates the test is applied to each distribution company. This new methodology is no longer adopted on a voluntary basis; it is compulsory. However, companies can claim *force majeure* event classification if they suffer damages to the network components due to weather conditions beyond the network design requirements only for cases when the method is not able to detect a single, localised cause of interruption that is not big enough to trigger the exceptionality test (for example, avalanches or strong winds for which DSOs must provide appropriate documentation proving that design limits have been exceeded).

2.7.2 Exceptional events visibility in the interruptions statistics

Previously, we concluded that the concept of exceptional events reflects the unique characteristics of each country's electricity sector and the impact of severe weather conditions in each country. However, it is important to understand how the exceptional events are taken into account in the interruption statistics in order to understand the meaning of the various countries' interruption indices, how these events affect the interruption level experienced by customers and what the system operators' responsibilities are in each country. Table 2.13 presents, inter alia, whether exceptional events are visible in the interruptions statistics or not, i.e., whether exceptional events are included in the interruption statistics, excluded or simply are presented separately in the statistics.

As has already been mentioned in this section, continuity of supply indicators present information on grid performance at the delivery points. If all interruptions are considered in the indicators calculation, they will provide information on the continuity of supply as seen by the customers, which is important in evaluating the impact of the exceptional/force majeure events in terms of continuity of supply.

As an example, the continuity of supply data from two countries was analysed, and the contributions of exceptional/force majeure events was assessed. One country considered exceptional events in the interruption statistics (Austria); the other country considering force majeure in the interruption statistics (Portugal). The next 4 figures show the interruption data analysed for this purpose.

FIGURE 2.11 MINUTES LOST PER CUSTOMER IN AUSTRIA DUE TO UNPLANNED INTERRUPTIONS

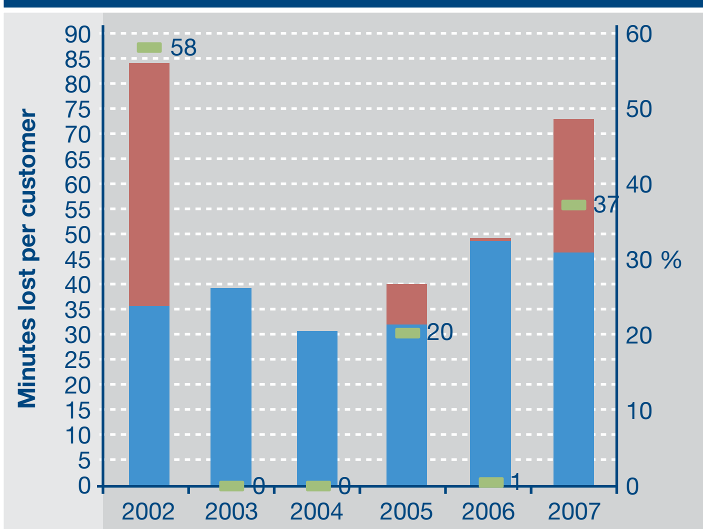
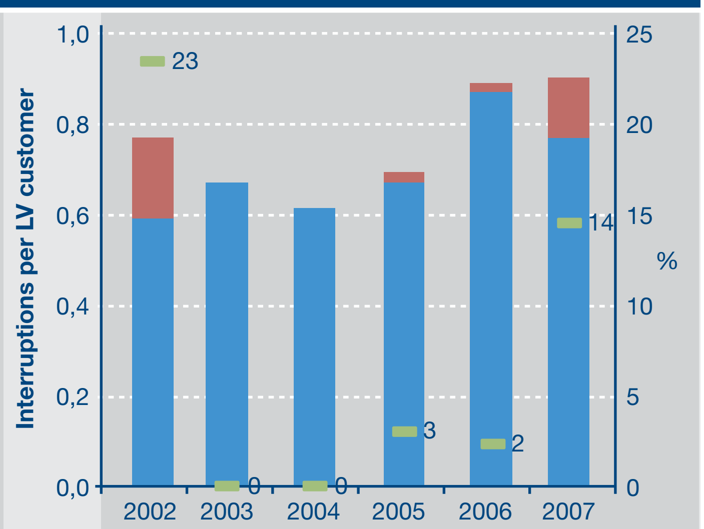


FIGURE 2.12 NUMBER OF INTERRUPTIONS PER CUSTOMER IN AUSTRIA DUE TO UNPLANNED INTERRUPTIONS



Interruptions attributable to exceptional events
Interruptions not attributable to exceptional events
% exceptional events

FIGURE 2.13 MINUTES LOST PER LV CUSTOMER IN PORTUGAL DUE TO UNPLANNED INTERRUPTIONS

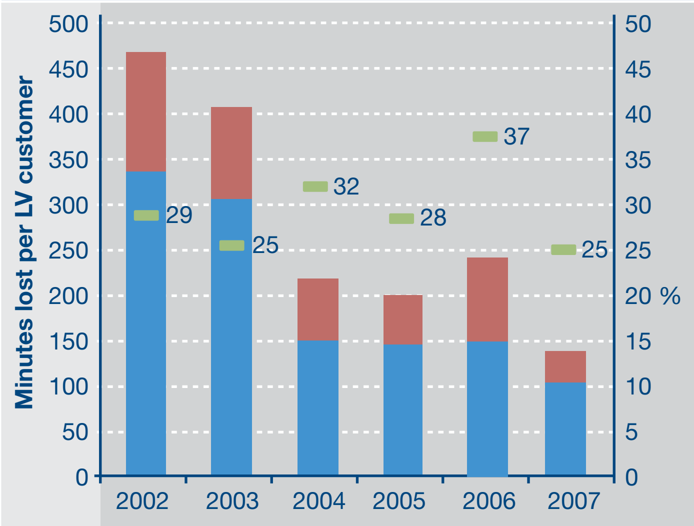
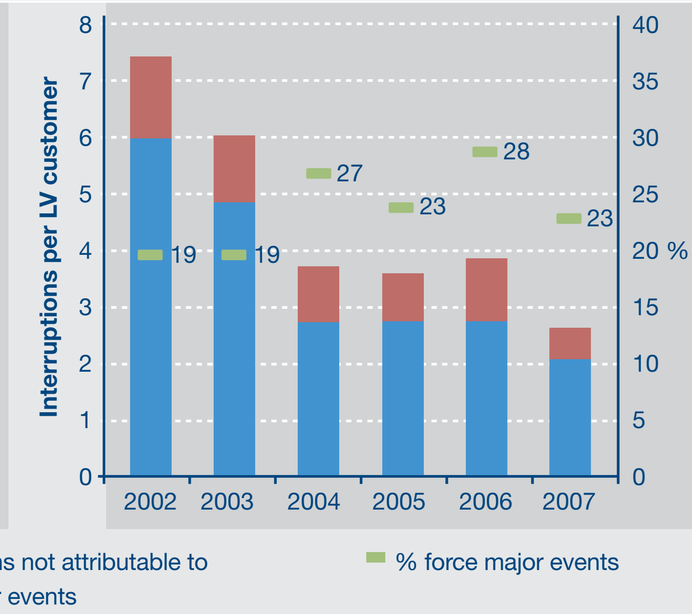


FIGURE 2.14 NUMBER OF INTERRUPTIONS PER LV CUSTOMER IN PORTUGAL DUE TO UNPLANNED INTERRUPTIONS



The previous figures highlight the distinction between the exceptional event and the force majeure event concepts in the two countries.

Even though Austria's exceptional event classification is not based on a statistical definition, the exceptional event classification has not been applied during half of the analysed years. In the years that the concept has been applied, it has been applied to only one specific incident. During the analysed years, the causes that justified the classification of exceptional events where:

- 2002 - August, flood (Danube)
- 2005 - August, flood (Salzburg, Tirol)
- 2006 - 4th November (UCTE interruption)
- 2007 - 19th January, storm (Kyrill)

From Figure 2.11 and Figure 2.12 we can see that these exceptional events represent from about 20% to 58% of the total ASIDI value and from 2% to 23% of the ASIFI value.

On the other hand, in Portugal, incidents that are classified as force majeure occur every year, several times per year. From Figure 2.13 and Figure 2.14 we can see that the annual contribution of force majeure events is from 25% to 37% of the SAIDI value and from 19% to 28% of the SAIFI value, both evaluated on LV customers.

This example shows the impact of the incidents classified as exceptional/force majeure events on the level of the continuity of supply in each one of the analysed countries. It also shows the differences for the values of the continuity of supply indicators that are reported when the exceptional/force majeure events are excluded.

2.7.3 Exceptional events and compensation payments

Table 2.13 shows whether different exceptional events in use in various countries are excluded from the calculation of any compensation paid to customers. The information gathered from the CEER member countries shows that no compensation is paid in many countries. However, in other countries it is considered that even when the interruptions are due to exceptional events, the affected customers must be compensated.

Table 2.14 gives 2 examples on how exceptional events are considered in the continuity of supply standards related to the maximum yearly duration of long interruptions.

TABLE 2.14 EXCEPTIONAL EVENTS IN CONTINUITY OF SUPPLY STANDARDS IN USE IN ITALY AND UNITED KINGDOM

Country	Standard: maximum yearly duration of long interruptions		Amount	Exclusions or exceptions
	Normal conditions	Exceptional events		
Italy	Standard applied even in exceptional conditions. LV High density area: 8 hours Medium density area: 12 hours Low density area: 16 hours MV High density area: 4 hours Medium density area: 6 hours Low density area: 8 hours (low density: municipalities with less than 5,000 inhabitants; medium density. between 5,000 and 50,000 inhabitants; high density: more than 50,000 inhabitants)		The value depends on the customer type (domestic or non-domestic), the installed power, the voltage level and the duration of the interruption. For example, for domestic customers, the compensation is equal to € 30 plus € 15 for each further period of 4 hours.	All events are included (even transmission-related events and exceptional events) Sole exclusion: evacuation of the population (for instance after an earthquake): in this case no compensation is due (in case of forced evacuation it is not meaningful to restore supply quickly)
United Kingdom	18 hours(normal weather conditions)	Intermediated events: 24 hours Large events: still 48 hours Very large events: more than 48 hours	£ 50 (domestic customers) or £ 100 (non-domestic customers), plus £ 25 for each further 12 hours up to maximum of £ 200 (all types of customers) Intermediated events, large events and very large events: £ 25 plus £ 25 for each further 12 hours up to maximum of £ 200 (all types of customers)	More than 500,000 customers affected per DSO Islands: Orcadi/Shetland and Highlands Exclusion of non-weather conditions Exception for “delay of clock”

The system operator is always responsible for a technical and economically efficient answer to the consequences of the occurred exceptional events. This premise is included in the procedures adopted in all countries; examples from 2 countries are presented below.

- In Estonia, when an interruption is caused by an event of long-duration (example: natural disaster, heavy winds or glazed frost that exceeds design norm, war ...) that could not be anticipated by the system operator, the event is declared an exceptional event. However, the system operator is obliged to act to restore service within 3 days of the end of the event. If the period of 3 days is exceeded, the system operator must compensate customers from its own profits.

- In Italy, as a general rule DSOs are responsible to compensate customers for interruptions that exceed standards for maximum duration of interruptions. For interruptions due to exceptional events, reimbursements are not paid by the utilities; in these cases, the costs are socialised and paid by a general interest fund. The general interest fund reimburses the distribution company under one of the three following situations:

  - For interruptions occurring during an exceptional period (EP) or caused by force majeure (in this last case, only if network components have been damaged; the distribution company must have written evidence that network design criteria have been exceeded);
  - For the period of time called "suspension of clock" when the "clock" counting the interruption duration may be suspended because the utility considers that it is not safe for repair teams to carry out the necessary work to restore the supply;
  - Interruptions due to external causes: (damages from third parties, interruptions caused by customers).

This general interest fund has been created with contributions from customers and regulated utilities. Customer contributions are part of the distribution tariff. Distribution companies contribute with payments that are a function of the number of their LV customers affected by interruptions longer than 8 hours in the previous year.

2.7.4 Measures adopted to minimise the occurrence of exceptional events and its impact on the network

Being conscious of the impact of exceptional events on the network performance and operation, system operators tend to adopt measures to minimise their occurrence or their impact on the network, adopting namely contingency plans and insurance contracts.

In many countries, there are two levels of contingency plans: a system operator contingency plan and a national contingency plan.

Additional information A 2.2 - Contingency plan in France

In France, the system operator contingency plan concerns the impact of exceptional events on the network and, in a general way, its aim is to reduce the interruption time, to minimise the energy not supplied/distributed and to minimise the number of affected customers.

As an example, in France, the contingency plan consists of a special emergency procedure including equipment, logistical organisation, cooperation planning between operators (sharing information and equipment...). The plan is established with the objective of restoring "normal" service within 5 days. Any major event due to extreme climatic conditions is followed by feedback from the DSO/TSO to the Ministry, making it possible to revise the technical rules (insulation distance, resistance to wind). These new rules apply to the new network elements. For the existing elements, an update programme is set up. This programme enables the DSO/TSO to carry out an inventory and to identify the modifications required to make the network meet these new standards. For example, following the storm in 1999, a plan for mechanical security was set up in order to reinforce the network in case of storms of similar intensity. It was financed by the use of system tariff for a total value of € 100 million per annum over 15 years.

In the German case, there is no national contingency plan in force. The existence of company contingency plans depends on the size of the DSO.

In some other countries, contingency plans are established explicitly by law and regulation. In Luxembourg, both national and company contingency plans are required by law. In Italy, distribution companies must prepare a contingency plan (emergency plan) for responding to exceptional events, following the guidelines issued by CEI - Comitato Elettrotecnico Italiano on behalf of the regulatory authority. The aim of the emergency plan is to ensure that the duration, geographic extent and consequences of the interruption is kept to a minimum for the effected customers.

In most countries, the national contingency plan is related to security situations that involve a group of national security bodies in addition to the system operators.

This separation between network contingency plans and the national contingency plan contributes to the distrinction between the two types of exceptional events in Norway:

- In the "contingency plans", the grid companies should focus on actions to be taken to prevent or to reduce the consequences of "Extraordinary situations". This might include investment in reserve material or other reserve capacity.
- The "Highly critical power situations" should be considered in the national power system planning. The energy and power balance should be analysed and actions taken to reduce the consequences.

The operators may adopt procedures and systems with the objective of reducing the time / number of occurrences or to minimise the impact of these incidents on the network. After the major incidents that occurred in the last few years, the use of the Dispatcher Training Simulator (DTS) has been recommended for use by the system operators. This computer-based training system allows network simulations, which help train the system operator technicians to act in crisis situations. This type of simulation system is implemented in Portugal, Hungary, Norway, Finland and Luxembourg. A similar system is in an advanced stage of implementation at the National Power Dispatcher of Romania. In France, the TSO has a training programme for crisis situations.

Insurance contracts are also used to provide coverage for the consequences of an exceptional event. By law, the system operator normally has an obligation to offer insurance contracts supporting its activities.

The Portuguese transmission operator has two types of insurance policies. One of them is imposed by law and concerns the civil responsibility against third party losses. The other one is optional and is an "all-risk" insurance against damages in the network (breakdown equipment in all substations). The insurance contract no longer covers line damages, as the premium was raised after the 1999 incidents in the French network, making the insurance uneconomic. Since 2004, in order to respond to emergency situations in lines, the Portuguese transmission operator has a "kit of emergency lines" (up to 400 kV), that can be rapidly installed for lengths between 6 and 8 km.

2.7.5 Main findings on exceptional events

In accordance with the responses received to the CEER questionnaire, the concept of exceptional events is commonly used, but it is applied with different designations and meanings. Therefore, it is not possible to derive a clear conclusion on situations where the concept is applicable and on how to distinguish between "exceptional events" and "normal interruptions".

Most of the analysed countries use the classification of force majeure. In many cases, the definition of force majeure is established in the civil law that is applied in a general way for many activities; it is not restricted to the electricity sector and continuity of supply regulation. In this context, the definition of force majeure is normally related to the system operator's responsibilities. While this is a factor that must be taken into account, it does not mean that a force majeure event should be summarily excluded from the quality of supply regulation. Moreover, the force majeure event classification is usually related to the causes of the incidents. Nevertheless, when an incident is classified as a force majeure event, the lack of quality (namely number and duration of interruptions) due to that incident is dependent on actions taken by the system operators. It is important that this aspect of the event is not overlooked. The classification of a situation as a force majeure event should only be accepted when the incident is well-justified and the relation between the causes and the effects of the continuity of supply performance has been proven. The required procedures for clarifying these situations are generally burdensome for the system operators and for the NRA.

As shown in this section, the exceptional event concept is used in most countries related to an unlikely occurrence, based on statistical methods. Statistical methods can be based on the level of exceptional impact of the weather conditions or it can be based on criteria such as the number of customers interrupted or the duration of the interruption.

Some countries have adopted a list of situations which would be considered exceptional events. In these cases, the definition should be sufficiently clear, such that there are no ambiguities when the classification is applied; borderline situations should be minimised. In some countries, regulators take decisions on a case by case basis, using general guidelines.

Despite the conceptual differences, various types of exceptional events have been identified because they are in use in different countries and have different impacts on the continuity of supply regulation in force in different countries. Understanding the meaning of these situations in each country and their influence on interruption statistics is of significant importance in a benchmarking study. Ideally, it would be desirable to have a harmonised definition. However, it is recognised that there are some environmental conditions and structural network characteristics that make this impossible. For example, within Europe, the climate conditions are very different between regions, making it difficult to set out a European definition of exceptional events using criteria based on weather conditions. The criteria based on statistical approaches could be more easily standardised all across Europe.

Some countries include exceptional events in their interruption statistics, while others do not. Some countries include separate numbers for exceptional events and interruption data, both with and without exceptional events. These aspects are of paramount importance when evaluating a benchmarking on continuity of supply and must always be taken into consideration.

It is recommended that any publication of continuity of supply data includes information about the interruptions that are excluded and included, together with information about those situations that are treated specifically. It is also recommended that each country use the definitions as set out in their own regulation. The use of expressions, like exceptional events, with an apparent intuitive meaning, but without a clear definition of the manner in which it is being used can result in misinterpretation.

The system operator is responsible for the network management and all the procedures to be taken, in order to minimise the effects of events that are outside the control of the system operators.

2.8 Conclusions and Recommendations on Continuity of Supply

Monitoring schemes for continuity of supply are in place in at least 21 European countries. The CEER is aware that several countries that have not replied to the questionnaire also have a monitoring scheme in place. The presence of a monitoring scheme for continuity of supply, controlled by an independent entity, like a regulator, is seen as an essential condition for a well-functioning electricity market.

Short interruptions are monitored by approximately half of the countries that replied to the questionnaire. It is strongly recommended that some type of monitoring scheme for short interruptions is in place as customers have placed increased importance on fewer and shorter interruptions. The CEER is aware that additional costs may be associated with such a scheme. This will, inter alia, depend upon the registration and reporting scheme that is currently being used for long interruptions. A decision on the implementation of such a scheme and the required accuracy of the resulting statistics can only be made at the national level. Furthermore, it is necessary to develop a clear aggregation rule for short and long interruptions that occur within a short timespan.

Only 2 countries collect statistics on transient interruptions. The usefulness of these statistics is recognised. However, a decision on this should be taken at a national level. The CEER offers no recommendations on this issue. The costs for implementing such a scheme should be considered in the decision.

Most countries collect some information on the cause of interruptions. This information is important for the regulators and is essential to enable system operators to improve the continuity of supply. Such information should be, and probably is, collected by system operators, in as much detail as possible. The CEER does not deem it important to harmonise the types of causes that are collected among the European countries.

The same reasoning holds, to a somewhat lesser extent, for information on the voltage level at which an incident took place. Different voltage levels may be operated by different companies, making this information relevant for regulatory purposes only.

Only a limited number of countries consider incidents at all voltage levels in the continuity of supply statistics. The absence of incidents at LV is seen as a serious limitation. Although incidents at MV provide the main input to SAIFI and SAIDI, incidents at LV cannot be neglected even for low voltage customers; the resulting interruptions often last longer than interruptions due to incidents at higher voltage levels. All countries are encouraged to include incidents at LV in the continuity of supply statistics. If the duration of those interruptions and numbers of affected customers are estimated, the additional costs are limited. A decision at national level is needed about automated methods for determining the duration of incidents at LV and number of affected customers. The costs of such a scheme should be considered in that decision.

Countries that do not monitor incidents at LV are encouraged to investigate the use of electronic energy meters (known as “smart meters”) in an automated scheme for logging interruptions. Additional advantages of such a scheme are that short interruptions can be recorded without extra costs and that weighting is automatically calculated based on the number of customers affected.

The use of different weighting methods for indices with the same term (SAIFI, SAIDI) makes comparison difficult. It is recommended to reserve the terms SAIFI and SAIDI for weighting based on the number of customers. Other terms should be used when other weighting methods are used. The use of different terms for the same index (SAIFI/SAIDI versus CI/CML) can also be somewhat confusing, but it is not seen as a significant concern.

The use of common definitions for SAIDI and SAIFI for all countries, as well as common rules for aggregation, weighting, etc., would certainly allow better comparisons of the continuity of supply among different countries.

It is also recommended that standards organisations, like CENELEC and IEEE, provide common definitions to reduce the confusion. The ongoing revision of IEEE Std.1366 and similar activities ongoing within CENELEC should be used as an opportunity to define the indices used in the different European countries in a standardised way.

No information was requested on aggregation rules used for counting long and short interruptions. In a parallel study, not reported in this document, large differences between European countries were observed. This will result in significantly different values for the number of interruptions per customer, especially for short interruptions. Harmonisation of aggregation rules is strongly encouraged.

In some countries no clear aggregation rules exist. The CEER recommends that these countries define such rules, preferably in harmonisation with other countries, especially for short interruptions.

The different rules and definitions used by different countries make it difficult to do a direct comparison of the continuity of supply in different countries.

A number of European countries have shown significant improvements in continuity of supply during the last 10 years. An inventory of the means by which this improvement was achieved would be useful information for other countries. Implementing these improvements in other countries could result in the next round of improvements in the continuity of supply.

3 VOLTAGE QUALITY

3.1 Introduction

Voltage quality was extensively covered in the 3rd Benchmarking Report on Quality of Electricity Supply. Issues related to NRAs' requirements for voltage quality, individual verification and market mechanisms for improving voltage quality in the various countries have not undergone major changes since the 3rd Benchmarking Report. In this chapter on voltage quality, the parts regarding these issues are based on the 3rd Benchmarking Report and upon amendments reported from the countries in 2008. The comparison of different voltage quality monitoring schemes has been extended in this edition of the Benchmarking Report. For the first time, it includes data on actual voltage quality levels submitted by the CEER member countries.

This chapter begins with a general introduction to the subject, explaining what voltage quality is, how it is affected and what it affects; further, standards and requirements in general are described. The main conclusions from the 3rd Benchmarking Report have been drawn up and there is a description of the CEER work on voltage quality matters in Europe since the 3rd Benchmarking Report was published in December 2005. The chapter also contains a comparison of voltage quality regulations (including requirements) and monitoring schemes running in the CEER member countries and data on actual voltage quality levels submitted from those countries, where such are available. Results from surveys conducted into costs due to poor voltage quality are presented from a few countries.

Table 3.1 presents the countries that provided information about one or several aspects of voltage quality regulation and voltage quality levels. The table gives an indication of what kind of information was provided.

TABLE 3.1 INDICATION OF WHAT KIND OF VOLTAGE QUALITY INFORMATION HAS BEEN PROVIDED BY DIFFERENT COUNTRIES

	National regulations different from EN 50160	Requirements above 35 kV	Individual voltage quality verification	Power quality contracts	Requirements about the use of monitoring devices	Surveys on customers' costs	VQ monitoring systems in operation	Data on actual VQ levels	Information on publication of VQ data	VQ monitoring systems planned
Austria		Yes	Yes							Yes
Belgium		Yes	Yes		Yes		Yes		Yes	Yes
Cyprus			Yes							
Czech Republic			Yes	Yes			Yes		Yes	Yes
Denmark							Yes			
Estonia			Yes							
Finland			Yes							
France	Yes	Yes	Yes	Yes	Yes (3)		Yes	Yes	Yes	Yes
Germany				Yes (1)						
Greece							Yes		Yes	
Hungary	Yes	Yes	Yes				Yes	Yes		

TABLE 3.1 INDICATION OF WHAT KIND OF VOLTAGE QUALITY INFORMATION HAS BEEN PROVIDED BY DIFFERENT COUNTRIES

	National regulations different from EN 50160	Requirements above 35 kV	Individual voltage quality verification	Power quality contracts	Requirements about the use of monitoring devices	Surveys on customers' costs	VQ monitoring systems in operation	Data on actual VQ levels	Information on publication of VQ data	VQ monitoring systems planned
Ireland		Yes								
Italy			Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Latvia			Yes	Yes						
Lithuania			Yes							
Luxembourg							Yes			
the Netherlands	Yes				Yes		Yes	Yes	Yes	Yes
Norway	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Poland		Yes	Yes							
Portugal	Yes	Yes	Yes	Yes	Yes		Yes		yes	
Romania		Yes	Yes	Yes						
Slovenia		Yes		Yes						
Spain	Yes			Yes						
Sweden						Yes (2)				
United Kingdom				Yes						

(1) In Germany, power quality contracts are optional on a contractual basis.
(2) The Swedish regulator submitted the information regarding the customer survey in Sweden but the survey was not performed by the NRA.
(3) In France, for the DSOs only.

3.2 Voltage Quality in General

Electricity consists of currents and voltages and has several characteristics which determine its technical quality, which means its availability and usefulness. In this report, the availability is dealt with in the chapter on continuity of supply. The usefulness of electricity when there are no interruptions is described by the level of the voltage quality. Voltage quality is becoming an important issue in many countries due to, inter alia, an increase in the sensitivity of end-user equipment over the past 20 to 30 years, and therefore it is of increasing concern to network companies, electricity end-users and electricity regulators.

In order to decide whether the voltage quality is good or poor, it is necessary to have stated criteria. The voltage quality is evaluated against these criteria and expressed with respect to them. Such evaluation criterion should consist of the parameter to be measured, the measurement period, the index to be calculated and the limit with which the index is to be compared. However, important items have to be considered during the development of such criteria, which will function as minimum requirements.

IEC[4] standards, which are worldwide standards, define an electromagnetic disturbance as any electromagnetic phenomenon which, by being present in the electromagnetic environment, can cause electrical equipment to depart from its intended performance. In this report, the term voltage disturbance

4 IEC = International Electrotechnical Commission (www.iec.ch)

will be used for the characteristics of the voltage. Different voltage disturbances are listed and defined in several international standards, but they are not always defined in the same way. Different voltage disturbances may be grouped according to the voltage frequency, RMS[5] value and wave shape, as presented in Table 3.2.

TABLE 3.2 VOLTAGE DISTURBANCES GROUPED ACCORDING TO THE DEVIATION IN THE FREQUENCY, THE RMS VALUE AND THE WAVE SHAPE

Voltage characteristics		
Voltage frequency	Frequency and time deviation	
Voltage RMS value	Slow voltage variations	
	Rapid voltage variations	Voltage dips
		Voltage swells
		Rapid voltage changes
		Voltage fluctuations (flicker)
Voltage wave shape	Harmonic voltages	Harmonic voltages
		Interharmonic voltages
		Subharmonic voltages
	Transient over-voltages	
	Mains signalling superimposed on the supply voltage	

3.2.1 Continuous phenomena versus voltage events

From a regulatory point of view, it is useful to group the different voltage disturbances mentioned above into continuous phenomena and voltage events. For each quality parameter to be regulated, it is important that it can be observed, quantified and verified.

- **Continuous phenomena** are voltage variations that occur continuously over time. Continuous phenomena are mainly due to load pattern, changes of load or nonlinear loads. They occur continuously over time and can often be satisfactorily monitored during measurement over a limited period of time, e.g. 1 week.
- **Voltage events** are sudden and significant deviations from normal or desired wave shape or RMS value. Voltage events are typically due to unpredictable events (e.g. faults) or to external causes. Normally voltage events occur only once in a while. To be able to measure voltage events, continuous monitoring and the use of predefined trigger values are necessary.

The voltage disturbances listed above can be grouped into continuous phenomena and voltage events as shown in Table 3.3 (brackets for some disturbances indicate that due to different causes they can be categorised partly as both).

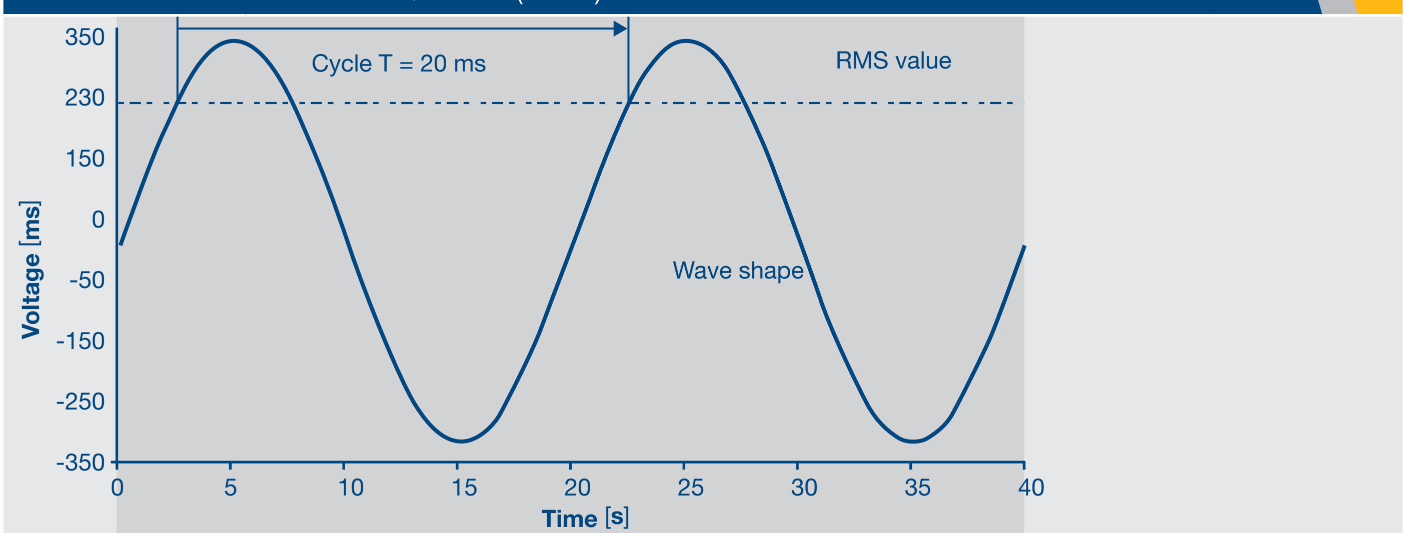
5 RMS = root mean square

The perfect voltage quality would be provided by a supply voltage with a perfect sine wave that had a nominal magnitude, angle between line voltages and frequency; see Figure 3.1 (only for a single phase). Any deviation causes a reduction in the voltage quality with respect to the perfect voltage quality. Many factors may reduce the voltage quality, e.g. short circuits and earth-faults, lightning, switching of capacitor banks, load variations, nonlinear loads (frequency converters, rectifiers), electronic equipment and the direct online start of large motors. To what degree the current flowing through the system will influence the level of the voltage quality at one point in the system will depend upon the system impedance or in other words the short circuit power[6] in that particular point in the system. Most electrical equipment is designed to tolerate some deviation from the perfect sine wave. It is not necessary and would not be socio-economically defensible to aim at a completely perfect voltage quality in the public electricity supply.

TABLE 3.3 VOLTAGE DISTURBANCES GROUPED INTO CONTINUOUS PHENOMENA AND VOLTAGE EVENTS

Continuous phenomena	**Voltage events**
Frequency and time deviation	Voltage dips
Supply voltage variations	Voltage swells
Voltage unbalance	Transient over-voltages
Harmonic voltages (including interharmonics and subharmonics)	
Mains signalling superimposed on the supply voltage	
Flicker (due to Voltage fluctuations)	
Rapid voltage changes	
(Voltage dips)	(Frequency and time deviation)
(Voltage swells)	(Rapid voltage changes)

FIGURE 3.1 TWO CYCLES OF A PERFECT SINE WAVE 50 HZ (S^{-1}) AC (ALTERNATING CURRENT) VOLTAGE WHERE THE RMS VALUE IS 230 V. THE FIGURE ALSO SHOWS THE CYCLE TIME WHICH IS THE INVERSE OF THE FREQUENCY (50 HZ)



6 The short circuit power (S_{sc}) is given as $S_{sc} = \sqrt{3}.U_N.I_{sc} = U_N^2/Z_{sys}$, where Z_{sys} is the system impedance consisting of the total impedance in generators, motors, transformers, cables, lines, etc. seen from a particular point in the power system.

Small continuous variations will always occur in the system. Still, system operators can do a lot to keep continuous variations within reasonable limits which eventually may lead to more efficient network management, e.g. lower power losses. Continuous phenomena outside predefined limits may lead to severe problems for connected customers. Voltage events may lead to an interruption in the processes within a customer's installation or to equipment damage; hence large costs for the customers can be involved. Voltage events may also result in equipment damage. Voltage events occur very randomly over the year and must be approached stochastically. System operators may introduce some measures in order to reduce the scope of voltage events, but voltage events can never disappear completely. Furthermore, it is important that customers are aware of the kinds of voltage events and the possible diffusion that may occur, and are therefore able to introduce appropriate counter-measures.

3.2.2 Influence on the voltage quality

Voltage quality is a complex and multi-dimensional issue, affected by several factors. Due to the nature of electricity, the voltage quality is affected by all the parties connected to the power system: network companies (DSO/TSO), power producers and end-users.

Voltage quality is influenced by the current flowing through the power system. The system impedance, and hence the short circuit power, is therefore of imperative importance regarding how different events and different load patterns influence the voltage quality. For example, the effect on the voltage quality due to customers' withdrawal of current will depend on the short circuit power at the point of connection. A key question when the voltage quality is too poor is whether the disturbance (e.g. a harmonic disturbance) from a customer's installation is too big or whether the short circuit power in the point of connection is too weak.

Network management is very important for voltage quality. Network design and operation, protection strategy, relaying and grounding, etc., are all key points for disturbances related to voltage quality. The role and actions of grid companies - both distribution and transmission operators - are therefore of paramount importance. Tasks relating to standards and regulations, amongst others, define the different parties' responsibilities.

3.2.3 Requirements for and regulation of voltage quality

The aim must be to have an electromagnetic environment where electrical equipment and systems function satisfactorily without introducing intolerable electromagnetic disturbances that would affect other equipment. This situation is referred to as electromagnetic compatibility (EMC). In order to achieve this, it is necessary to limit specific voltage disturbances in the public supply voltage, taking into account in particular international EMC standards issued by the IEC regarding immunity and emission limits. The EMC framework is applicable to continuous phenomena but has not yet been developed for voltage events. In the book "Service Quality Regulation in Electricity Distribution and Retail"[7] more information can be found about possible regulatory instruments regarding quality of supply.

In Europe, the most important norm regarding voltage characteristics of electricity supplied by public distribution networks is the CENELEC[8] norm EN 50160[9]. This norm defines, describes and specifies

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7 This book has been the collective effort of scholars and practitioners of the Florence School of Regulation (FSR) and the CEER. The authors are E. Fumagalli, F. Delestre and L. Lo Schiavo. Available for purchase from www.springerlink.com, ISBN: 978-3-540-73442-0.

8 European Committee for Electrotechnical Standardization (www.cenelec.org). CENELEC norms are available from CENELEC and from the different national standards organisations (national members of CENELEC).

9 EN 50160:2007 Voltage characteristics of electricity supplied by public distribution networks.

the main characteristics of the voltage at a network user's supply terminals in networks with voltage levels below 35 kV. The limits in EN 50160 are mainly given for only a percentage of the time and often softened by using "should" instead of "shall". The original scope of the EN 50160 was to only define and describe the characteristics, which is part of the reason why the limits are not yet satisfactory for regulatory use. EN 50160 is currently under revision; see section 3.4 for further information.

Regarding standardised methods for measurements of voltage quality, the most important norm worldwide is the IEC norm 61000-4-30[10], which is also adopted by CENELEC without corrections and functions as a CENELEC standard EN 61000-4-30. The table below lists the voltage disturbances given in the present edition of EN 50160, the new draft EN 50160 under consultation and in the IEC 61000-4-30. Throughout the rest of this chapter, the terms in the new draft EN 50160 will be used when referring to different voltage disturbances.

TABLE 3.4 VOLTAGE DISTURBANCES LISTED IN THE NORMS EN 50160 AND IEC 61000-4-30.

Voltage disturbances listed in the present EN 50160	Voltage disturbances listed in the new draft EN 50160	Voltage disturbances listed in IEC 61000-4-30(1)
Power frequency	Power frequency	Power frequency
Magnitude of the supply voltage	Magnitude of the supply voltage	Magnitude of the supply voltage
Supply voltage variations	Supply voltage variations	Supply voltage variations
Flicker	Flicker	Flicker
Supply voltage dips	Voltage dips	Supply voltage dips
Temporary power frequency overvoltages between live conductor and earth(2)	Voltage swells(2)	Supply voltage swells
Transient overvoltages	Transient overvoltages	Transient voltages
Voltage unbalance	Voltage unbalance	Supply voltage unbalance
Harmonic voltage	Harmonic voltage	Voltage harmonics
Interharmonic voltage	Interharmonic voltage	Voltage interharmonics
Mains signalling voltage	Mains signalling voltage	Mains signalling voltage on the supply voltage
Single rapid voltage change	Single rapid voltage change	Rapid voltage changes

(1) IEC 61000-4-30 gives definitions without giving the threshold values.
(2) In the present EN 50160, temporary overvoltages are only defined between live conductors and earth and without any threshold values or minimum and maximum durations. In the new draft EN 50160, it is proposed to define voltage swells both between live conductors and earth and between live conductors, and also with threshold values and minimum and maximum durations. The new definition is in accordance with the definition in IEC 61000-4-30.

Any minimum requirements for voltage disturbances should be based upon (not in a prioritised order):

- Aim whether to uphold or to increase today's level of quality;
- The consequences or impact that each voltage disturbance will have on society in general, and the single grid customer in particular;
- The level of disturbances that leads to interference with electrical equipment. This will, inter alia, include damage, malfunction, changes in equipment lifetime and visual annoyance;
- Which voltage disturbances may easily be monitored and followed up in a suitable manner;

10 IEC 61000-4-30:2003 Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods.

- Provisions that apply for 100% of the time under normal operating conditions unless exemptions are granted;
- Compatibility with other standards, including international EMC standards.

Voltage quality is affected by all parties connected to the power system, because of the nature of electricity; see also section 3.2.2. Attention must therefore be paid to transmission and distribution companies, power producers and end-users.

Furthermore, it is important not to look upon any kind of minimum requirements as being the same as design criteria (planning levels). The system should be designed (planned) for a better quality than stated by minimum requirements, in order to ensure being able to fulfil the minimum requirements. Such planning levels may form internal quality objectives, aimed at managing customer emission levels and system characteristics, in order for the minimum requirements to be met.

3.3 Main Conclusions from the 3rd Benchmarking Report

Voltage quality was extensively covered in the 3rd Benchmarking Report on Quality of Electricity Supply issued in December 2005. One of the main findings in that report was the complexity of voltage quality and that good knowledge of the real situation is a preliminary step towards any kind of regulatory intervention. Already then, a significant number of the CEER member countries had installed, or were about to install in the near future, a monitoring system on voltage quality. Further, it was found that in most countries customers are generally entitled to have a verification of actual voltage quality levels at the point of connection.

Another main finding was that in some countries minimum requirements for voltage disturbances differ from the ones stated in the European norm EN 50160. This applied especially for continuous phenomena and was due to the fact that EN 50160 was found to be unsatisfactory both by regulators and by customers. It was further stated in the report that "some regulators think that stricter voltage quality standards are required or are actually engaged to prepare more constraining standards because they are not happy with EN 50160". The reasons for this view were stated but have been further elaborated in an ERGEG consultation[11] paper of December 2006 and an ERGEG conclusions[12] paper of July 2007.

Furthermore, it was found that in some countries power quality contracts can be entered into between companies and customers in order to agree upon contractual quality levels, extra-revenue for the distribution companies and payments to the customers if the quality levels are not met. Only in France and Italy was this regulatory tool developed with some ex-ante intervention of the regulator.

The 3rd Benchmarking Report on Quality of Electricity Supply gave three main recommendations for future work on voltage quality:

- It was highly recommended that EN 50160 be revised by CENELEC in cooperation with the CEER and other stakeholders, taking into account both the actual levels of voltage quality in European transmission and distribution networks, the evolution of customers' needs and the voltage quality measurements issues.

11 E06-EQS-09-03 ERGEG consultation paper: Towards voltage quality regulation in Europe, on consultation between 21st December 2006 and 22nd February 2007, www.energy-regulators.eu, see also section 3.4 below.

12 E07-EQS-15-03 ERGEG conclusion paper: Towards voltage quality regulation in Europe, ERGEG July 2007, www.energy-regulators.eu, see also section 3.4 below.

- It was strongly recommended that at least the most critical voltage disturbances be monitored and that results be published, in order to determine, in a first stage, the actual performance of networks. It was recommended that this was done over several years (at least 3), in order to draw out significant trends.
- It was highly advisable to undertake further research and to obtain further information on power quality contracts, which can result in an efficient way to satisfy special quality needs without increasing general tariffs.

These recommendations, and especially the first bullet point, have formed part of the work programme for the CEER in the years 2006, 2007 and 2008.

3.4 Work done by the CEER and ERGEG on Voltage Quality after the 3rd Benchmarking Report

In 2006, the European regulators started cooperation with CENELEC in order to revise the EN 50160. Representatives of the CEER attended a meeting of the CENELEC Technical Committee no 8X on 18th May 2006, and gave a presentation of the CEER and the European regulators' initial view on the EN 50160. The CEER was then further invited to attend meetings of the relevant working group (TC8X/WG1) inside CENELEC dedicated to the development of the norm EN 50160. The CEER representatives have participated actively in the work of this working group in order to revise the EN 50160 in a consensual way, according to CENELEC procedures.

On 29th September 2006, CEER organised a technical workshop on "voltage quality standards and regulations" in Milan, Italy. The workshop gathered representatives of CENELEC, EURELECTRIC and EICTA, together with academics and representatives from the research environment and from the CEER. The different stakeholders presented their views on voltage quality standards and regulations. The CEER presented preliminary statements on aims and needs for the regulators regarding voltage quality standards and regulation, and preliminary proposals for useful improvements in EN 50160 in order to reach such aims and needs. This workshop was an important step for further cooperation between stakeholders regarding revising the EN 50160.

Following a wide consultation process held by ERGEG between 21st December 2006 and 22nd February 2007, the ERGEG Conclusions Paper "Towards Voltage Quality Regulation in Europe" was published on 18th July 2007. The ERGEG paper contains the European regulators' position on several aspects of EN 50160 in need of improvements and identifies gradual steps in order to achieve such improvements.

The decision from the CEER to participate in the process for a revision of the EN 50160 is based on a widely-supported understanding that when available and suitable, international technical norms can be the best tool to complement national regulations. Therefore, the position stated in the Conclusions Paper "Towards Voltage Quality Regulation in Europe", is that EN 50160 can be used as a basis for national voltage quality regulations only if certain improvements are made. The only alternative to using proper international standards is for NRAs to issue national requirements on voltage quality, which a few countries have already done.

The afore-mentioned consultation paper contained seven recommendations to CENELEC about revising the EN 50160, namely:

1. Improve definitions and measurement rules;
2. Limits for voltage variations - Avoid “95%-of-time” clause and avoid long time interval for averaging measured values;
3. Enlarge the scope of EN 50160 to high and extra-high voltage systems;
4. Avoid ambiguous indicative values for voltage events;
5. Consider duties and rights for all parties involved;
6. Introduce limits for voltage events according to network characteristics;
7. Develop the concept of power quality contracts.

ERGEG received 27 written responses to the consultation paper within the deadline for sending replies, out of which 14 came from utilities or utility associations, and 10 came from voltage quality professionals, single experts, academics or research institutes. Only 1 response came from a customer association and 2 responses arrived from manufacturers. After the deadline for replying to the consultation, a response was received from a European association organising both utilities and customer organisations within European countries. All of the responses were appreciated and have been very valuable in the process of revising the EN 50160.

However, ERGEG notes that the consumers’ views have not been adequately represented in the consultation process and in the CENELEC work (through active participation). This can ultimately lead to underestimation of the benefits of revising voltage quality norms or over-evaluating costs that might be incurred by new norms. It is important to have a sound balance between all of the relevant stakeholders in the “world of standardisation”.

Based on the recommendations from the European regulators, several ad-hoc task forces have been launched, within WG1 of the CENELEC TC 8X, in order to explore possible solutions to the issues raised by the afore-mentioned Consultation and Conclusions Paper. These task forces have the following names and scopes:

- Voltage dips and swells (TF1)
- Enlarging EN 50160 scope to HV/EHV networks (TF2)
- Limits for supply voltage variations (TF3)
- Long and short interruptions (TF4)

Each of these task forces has contained or still contains representatives from EURELECTRIC, manufacturers, the research environment and the CEER. Such mini-task forces seem effective in order to reach possible compromises between different stakeholders. And in 2007 and 2008 effective work was carried out by these mini-task forces. The outputs of the first three mini-task forces have formed a new draft EN 50160 that was sent for consultation among national standardisation committees (members of CENELEC) at the beginning of April 2008 with a deadline for comments of 5th September. The CENELEC secretariat received quite a few comments on the draft. A meeting of the TC8X/WG1 on 23rd and 24th September 2008 decided upon amendments to the draft in order to try to reach a positive vote from the national norm committees. The TC8X decided, in a meeting on 22nd October 2008, that the new draft EN 50160 is mature enough for a vote. The output of the mini-task force on interruptions is aimed at forming a new technical report in the near future.

The WG1 meeting on 23rd and 24th September decided to close TF1, TF2 and TF3, and some new TFs were established:

- Short circuit power (TF5)
- Create the final voting document (TF6)
- Limits for faster phenomena (TF7)

The members of the mini-task forces TF5 and TF7 will only be decided at the next meeting of TC8X/WG1 which it is assumed will take place in May 2009, and the work will fully start only after that.

From the recommendations from the regulators to CENELEC mentioned above, numbers 1 to 4 were considered to be the most important and easiest to deal with in the short term. The new draft EN 50160 sent for consultation at the beginning of April contains some improvements within all of these 4 areas.

The CEER and CENELEC will sign a Memorandum of Understanding between the two organisations on 13rd January 2009, which formalises the already ongoing cooperation between the CEER and CENELEC and opens the possibility also to cooperate within other fields.

Through the work with revising EN 50160, the CEER and EURELECTRIC have also discovered the need for bilateral meetings regarding some quality of supply topics.

Further in 2006, the CEER, together with the Florence School of Regulation (FSR), developed a book regarding Service Quality Regulation[13]. This book includes important information, in particular for regulators, on how to develop regulatory instruments within one or several fields of quality of supply, and for anyone wanting to learn more about public regulation of quality of supply.

Finally, the CEER representatives have given several presentations in different fora about the results of the 3rd Benchmarking Report on Quality of Electricity Supply and the regulators' view regarding voltage quality regulation.

3.5 Voltage Quality Regulation

As stated in section 3.2.3, the terms used in the new draft EN 50160 will be used throughout this report. The voltage disturbances in the new draft EN 50160 are listed in table 3.4.

Power frequency is however not considered in this report, as the power frequency is monitored and managed by the interconnected European transmission system operators and international system operation agreements.

For the purpose of this section regarding requirements in the EN 50160, we refer to the 2007 edition (latest in force). EN 50160 is applicable in all EU and EEA countries for low and medium voltage networks up to 35 kV. However, the use of EN 50160 in national quality of supply regulations varies between countries. In almost all countries, previous editions of the EN 50160 have been translated.

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13 This book has been the collective effort of scholars and practitioners of the Florence School of Regulation (FSR) and the CEER. The authors are E. Fumagalli, F. Delestre and L. Lo Schiavo. Available for purchase from www.springerlink.com, ISBN: 978-3-540-73442-0.

3.5.1 National regulations that differ from EN 50160

EN 50160 sets mandatory values for compliance, which are stated for only a few voltage disturbances under normal operating conditions and only for a given percentage of time and mean values over long time intervals (typically 95% of the time and the 10 minute mean RMS values):

- Supply voltage variations (95% and 10 minute mean values);
- Flicker (95% and 2 hour values);
- Harmonic distortion of voltage waveform (95% and 10 min. mean values);
- Mains signalling voltage (99% and 3 second mean values).

Over the years, some regulators have introduced voltage quality limits that are different from those indicated in EN 50160. Table 3.5 lists the countries where national regulations differ from EN 50160, although in some cases these regulations or standards have not been set by the regulator. The list is separated into each type of voltage disturbance (excluding power frequency variations). More details can be found in Annex 2.

According to EN 50160, supply voltage variations shall, for 95% of the time during 1 week, be within ±10% of the nominal voltage U_n for LV (or the declared voltage U_c for MV) measured as 10 minute mean values. Only for LV, 100% of the 10 minute mean values during 1 week shall be within the +10%/ -15% of the nominal voltage. Although this limit is among the few enforceable ones set by EN 50160, some countries have introduced different, more restrictive limits for this voltage disturbance. The restrictions affect the "95% of time intervals", the time aggregation intervals and the tolerance band; see Table 3.5.

TABLE 3.5 NATIONAL VOLTAGE QUALITY REGULATIONS OR STANDARDS THAT ARE DIFFERENT FROM EN 50160

Voltage characteristics in EN 50160	Countries with a different regulation or standard
Supply voltage variations	ES, FR*, HU, NO (only for LV customers), PT (only for EHV-HV customers)
Flicker	NO (requirements for both Pst and Plt), PT (only for EHV-HV customers), NL (maximum limit for Plt)
Voltage dips	NO, FR* (customised engagement on request only for MV and HV customers)
Voltage swells	NO, FR*
Transient overvoltages	FR*
Voltage unbalance	FR*, NO, NL
Harmonic voltage	FR*, NO, PT (only for EHV-HV customers), NL (maximum limit for THD, 5th and 7th harmonic)
Interharmonic voltage	None
Mains signalling voltage	None
Single rapid voltage changes	NO

(*) In France, the voltage quality limits are set in the contracts between the customer and the distribution/transmission operator; the regulator surveys the contracts but does not set standards.

Some of the differences are elaborated below; please find further details in Annex 2:

- France:
  - Contracts for MV customers contain the voltage variation limit U_c ±5% for 100% of the time, where U_c must be in the range ±5% around U_n for 100% of the time;

- Concerning voltage variations on MV and LV networks, as from December 2007 (decree from the 24th December 2007), 10 minute mean values of voltage variations shall be within ±10% of the corresponding nominal value;
    - From October 2006 (decree from 6th October 2006), there are new standards in force relevant to connection points between the transmission network and distribution networks;
    - The threshold between interruption and dips is 8% of the contractual voltage.
- Hungary:
    - For LV networks, 10 minute mean values of the supply voltage variations shall be within U_n ±7.5% for 95% of the week and within U_n ±10% for 100% of the week;
    - For LV networks, each 1 minute mean value of supply voltage variations shall not be above U_n +15% and not below U_n -15%.
- Portugal:
    - For EHV and HV networks, the Quality of Service Code establishes that the value of U_c shall be within the range of U_n (7%). Under normal operating conditions, during each period of 1 week, 95% of the 10 minute mean RMS values of the supply voltage shall be within the range of U_c ±5%.
- the Netherlands:
    - For LV and MV networks, supply voltage variations shall be within U_n ±10% for 95% of the week and within U_n + 10/ -15% for 100% of the time with no exceptions for long lines or non-interconnected areas.
- Norway:
    - For LV networks, the network companies shall ensure that supply voltage variations at the points of connection are within U_n ±10% for 100% of the time, measured as 1 minute mean values. See also Table 3.7 for more information.
- Spain:
    - For LV and MV networks, supply voltage variations in the points of connection shall be within U_c ±7% for 95% of the time;
    - For supplies to distributors who are fed through 1-36 kV networks, the tolerances above shall be reduced to 80%.

Penalties are foreseen in only a few countries for cases in which the voltage quality limits are not met. In France, through contract conditions, customers can receive compensation payments on request if voltage quality contractual levels are not met. For instance, a customer with a customised contractual level on voltage dips can receive compensation if the operator does not respect this standard. This is also valid for EN 50160, when this is referred to in contracts. In other countries (like Hungary and Romania), in cases in which the voltage quality standards are not met, a financial penalty may be applied by the regulator. In Germany, financial penalties are negotiated individually, in the framework of bilateral agreements between customers and system operators. In others still, the distribution company must take appropriate steps to rectify the causes of the inadequate voltage quality within a given time (e.g. in Spain and in the United Kingdom the period is 6 months for voltage variations outside prescribed limits). Regulations and standards related to the companies' handling of voltage quality complaints and timeliness for restoring normal voltage quality limits on a local basis is a key regulatory measure. Further information about this is available in the chapter on commercial quality.

In some countries, the voltage quality regulation is also applicable to networks with voltage levels higher than 35 kV. Regulatory frameworks and provisions vary from country to country. Table 3.6 presents countries, where to some extent, the regulator has issued some rules relevant to voltage quality for networks with voltage levels higher than 35kV.

The most interesting case for voltage quality regulation is Norway, where in 2005 the regulator introduced a new regulation with some requirements stricter than EN 50160 (see Additional information A 3.1). The regulator decided to set limits for voltage disturbances after becoming very familiar with the subject. National research projects had provided several years of continuous monitoring, giving knowledge about actual voltage quality levels, and knowledge about when different voltage disturbances cause problems for end-users (above which level). This information was a good basis for introducing a better and a more detailed public regulation on quality of supply. It was focused on those voltage disturbances that it is possible (easiest) to prevent from exceeding their limits. The previous schemes for continuous monitoring that were achieved through national research projects depended also upon voluntary contributions from Norwegian distribution companies for more than 12 years.

TABLE 3.6 COUNTRIES WHERE THE VOLTAGE QUALITY REGULATION IS APPLICABLE TO NETWORKS > 35KV

Country	Voltage quality regulation applicable to networks > 35kV
AT, PL	As a consequence of the general terms and conditions of system operators
BE (Flanders region)	Up to 70 kV
BE (Federal and Walloon region), CZ, LU, SE	It applies, but no specific information applicable
IE, NO, PT, RO	All voltage levels > 35kV (for Norway and Portugal find more information below and in Annex 2)
DE, FR	As a consequence of bilateral agreements or quality contracts signed between customers and system operators
SI	TSO have to maintain such a voltage quality level in the network to enable the DSO to supply the quality according to EN 50160
HU, NL	Regulated by the Grid Code

Additional information A 3.1 - Regulations on Quality of Supply in Norway

The Norwegian regulator (NVE) put into force a new regulation on quality of supply from January 1st 2005. Some modifications entered into force in 2006 and some in 2007. The purpose of the regulations on quality of supply is "(...) to contribute to ensure a satisfactory quality of supply in the Norwegian power system and a social rational operation, expansion and development of the power system. This includes taking into account public and private interests affected."

The following were the aims of developing a national regulation in Norway with specific requirements for the quality of supply (not in order of priority):

- To obtain a quality of supply that is beneficial for society as a whole, and not only to cause a general improvement in the power quality;
- To define what level of quality is regarded as a satisfactory quality of supply. The actual level of the quality of supply in today's system was generally regarded as satisfactory. Requirements were therefore aimed primarily to describe today's quality level;
- To prevent an undesirable deterioration of the quality of supply due to an overall reduction in companies' costs after the introduction of incentive-based financial regulation (revenue caps);
- To improve the companies' knowledge about the actual power quality being supplied to the customers. Realistic reference levels are needed in order to at least allow customers to adopt their own counter-measures if they have special requirements for power quality;
- To provide a good basis for handling disputes between network companies and between companies and customers;
- To improve the end-users' legal rights regarding quality of supply, and to focus on the network companies' ability to supply services and electricity of a satisfactory quality.

When developing the Norwegian regulations, NVE noted the importance of compatibility between different regulations and (international) standards. Hence, the Norwegian requirements take into account both emission and immunity levels given in international standards. International standards were however found to be not satisfactory enough to refer to limits, although for measurement methods, relevant standards from CENELEC and IEC are referred to. The regulations on quality of supply define requirements for (in short):

- A minimum acceptable level of voltage disturbances at the point of connection;
- Continuous monitoring of voltage quality;
- Registration and reporting of short and long interruptions;
- Information to customers about historical power quality levels and future power quality levels to be expected;
- Time limits for handling and solving customers' complaints relating to power quality;
- Restoration of supply and rectification of violated limits without undue delay.

Regarding voltage quality, minimum requirements have been introduced for power frequency, supply voltage variations, voltage swells (exceptions for some causes), voltage dips (exceptions for some causes), rapid voltage changes (exceptions for some causes), flicker, voltage unbalance and harmonics.

The regulation embraces everyone that is connected to the power system, i.e. network companies, end-users and power producers. Due to the nature of electricity, it was considered important to have requirements for all parties that are connected to the power system. In more detail, the regulation applies to "those who wholly or partially own, operate or use electrical installations or electrical equipment that are connected within the Norwegian power system, and those who pursuant to the Norwegian Energy Act are the designated transmission system operator."

The regulation further points out that power quality shall be a part of the network contract between the network companies and their customers. Such a contract can be an important instrument to limit disturbances generated by customers so that the voltage quality requirements at all supply terminals can be managed.

The main differences between the Norwegian regulation on quality of supply and EN 50160 are given in Table 3.7.

TABLE 3.7 COMPARISON BETWEEN EN 50160 AND THE NORWEGIAN REGULATIONS ON VOLTAGE QUALITY PARAMETERS

Quality aspects	EN 50160			The Norwegian regulations on quality of supply		
Voltage level	[0,1] kV	<1,35> kV	[35,∞> kV	[0,1] kV	<1,35] kV	<35, ∞> kV
Supply voltage variations	230V ± 10% (10 min mean 95% of the week) 230V±10/-15% (all 10 min mean values)	U_c ± 10% (10 min mean 95% of the week)	None	230V ± 10% (all 1 min mean values)	None	None
Rapid voltage changes (RVC)	Indicative: Generally < 5% Up to 10%	Indicative: Generally < 4% Up to 6%	None	Maximum 24 per 24 hour - $\Delta U_{steadystate} \geq 3\%$ - $\Delta U_{max} \geq 5\%$ Exception for some causes.	Same as LV	Maximum 12 per 24 hour - $\Delta U_{steadystate} \geq 3\%$ - $\Delta U_{max} \geq 5\%$ Exception for some causes.

TABLE 3.7 COMPARISON BETWEEN EN 50160 AND THE NORWEGIAN REGULATIONS ON VOLTAGE QUALITY PARAMETERS

Quality aspects	**EN 50160**			**The Norwegian regulations on quality of supply**		
Voltage swells	Indicative: < 1.5kV (phase to earth)	Generally < 1.7 x U_c (earthed) Generally < 2.0 x U_c (isol./resonant.)	None	Same as RVC	Same as LV	Same as RVC
Voltage dips	Indicative: Few tens up to one thousand	Same as LV	None	Same as RVC	Same as LV	Same as RVC
Flicker	Plt ≤ 1 (95% of the week)	Same as LV	None	Pst ≤ 1,2 (95% of the week) Plt ≤ 1 (100% of the time)	Same as LV	Pst ≤ 1 (95% of the week) Plt ≤ 0,8 (100% of the time)
Voltage unbalance	≤ 2% (10 min mean 95% week) ≤ 3% occur in some areas	Same as LV	None	≤ 2% (all 10 min mean values)	Same as LV	Same as LV.
Harmonic voltage, THD	THD ≤ 8% (10 min mean 95% of the week)	Same as LV	None	THD ≤ 8% (all 10 min mean values) THD ≤ 5% (all mean week values)	Same as LV	<35, 230] kV: THD ≤ 3% (all 10 min mean values) <230, ∞>: THD ≤ 2 % (all 10 min mean values)
Harmonic voltage, individual	EN 50160 Table 1 (10 min mean 95% of the week)	Same as LV	None	Same as table 1 in EN 50160 but for 100% of the time. Plus general limits above 25th order. (all 10 min mean values)	Same as LV	Limits for all harmonic orders. General limits above 25th order. (all 10 min mean values)

Only voltage disturbances where the Norwegian regulation contains specific limits are included. For other voltage disturbances the regulator can also specify limits.

Voltage quality regulation might also do well to consider the problem of disturbing customers' plants. In Portugal, for instance, the Quality of Service Code imposes maximum levels of disturbance concerning voltage quality for installations connected to, or having applied for connection to, the networks. If one installation connected to the network has levels of disturbance greater than the limit, the system operator must notify the party in charge of the installation. The system operator must advise clients connected to its network on the best way to mitigate the pollution caused by their installations. But if the pollution due to a client damages the voltage quality, the system operator has to contact the client and agree on a deadline by which to solve the problem. If they fail to agree, the decision is submitted to the regulator (ERSE). If at the end of that time the problems remain or are causing serious damage, for instance related to the safety of other customers' equipment, the entity responsible for the network can disconnect the polluting installation. This situation must be communicated both to the regulator (ERSE) and to the governmental offices (DGGE).

Similar solutions are adopted in Spain and in France to ensure that consumers establish a set of measures to minimise the risks stemming from lack of quality. For these purposes, the distribution companies must inform the consumer in writing of the steps to be taken to achieve this risk minimisation. Defining allowed emissions to customers is a very complex matter that still needs to be studied profoundly, as it involves both the customer installations and the network characteristics, in terms of short circuit power at the connection point.

In Norway, everyone that is connected to the power system is covered by the quality of supply regulation, as already described above. If a customer's plant generates disturbances so that the limits set for voltage quality are exceeded at the point of connection for other customers, then the disturbing customer is obliged to rectify the problem without undue delay. Further, if a customer experience incidents in its own plant that are likely to generate voltage quality deviations above the limits set for each point of connection, the customer is obliged without undue delay to inform the network company to which the customer is connected. However, in an individual case it might be difficult to decide whether the disturbances from the customer are too high or whether the short circuit power of the power system is too low. If the network company and the customer do not agree on who is responsible for rectifying the situation, the case can be brought before the regulator (NVE). The regulator's decision can be appealed to the Ministry of Petroleum and Energy (OED).

In Italy, a Technical Standard (CEI 0-16) issued by the national standardisation body (CEI) sets the maximum inrush current for MV customers connected after September 2008 and the corresponding level of short circuit power to be assured by DSOs, in order to guarantee a maximum variation (5%) for rapid voltage changes.

3.5.2 Individual voltage quality verification

Although voltage quality monitoring systems are very useful for getting a general picture of actual levels of voltage quality, for a single customer it is more important to have a specific measurement of voltage quality levels at its own connection point. The reason is that one disturbance will cause different changes in the voltage quality levels (for instance, the depth of voltage dips) from one point to another even along the same circuit.

In most countries, customers who experience problems due to voltage disturbances can request a individual voltage quality verification for their connection point, although the distribution companies are not legally required in all countries to install a voltage quality recorder for a given time period; some details are presented in Table 3.8. Generally, costs are paid for by the requesting customer. However, sometimes costs are paid by the customer if the voltage deviations comply with regulations and standards in operation, and by the company if they don't (see also Additional information A 3.2), and for some countries the costs are always paid by the company if the request is due to, or a result of, a voltage quality complaint.

In a few countries, customers have the right to install their own voltage quality recorder instead of asking for it from the distribution company. Generally, the voltage quality recorder owned by the customer must comply with technical standards to be accepted by the distribution company. In some countries, the voltage quality recorder owned by the customer has to comply with several technical criteria, defined by the operator.

TABLE 3.8	INDIVIDUAL VERIFICATION OF VOLTAGE QUALITY
Regulatory framework for individual verification	**Country**
Distribution companies compelled to provide voltage quality individual measurements when requested by the customer or after complaints.	AT, BE, CY, CZ, DE, EE, FI, FR, HU, IT, LT, LV, NO, PL, RO, PT
Proposal stage	SE
No legal obligation	ES, UK, EL, LU, SL

Additional information A 3.2 - Individual verification of Voltage Quality in Portugal

When a client complains about voltage quality and the distribution operator does not have enough information to typify the waveform in the client delivery point, the operator has to make additional measurements. After the monitoring, the distributor has to give the client the following information:

- Monitoring period;
- Type of equipment that was used in the monitoring;
- Type of perturbations that have been registered;
- Analysis of the regulated values or limits fulfilment;
- Entity responsible for the disturbances;
- Deadline by which to solve the detected problem in cases in which code levels are not met.

The limits for voltage disturbances at the delivery point are established in NP EN 50160 (translation of the European Standard EN 50160) for LV and MV networks, and in the Complementary Instructions published by the Ministry (DGGE) in accordance with Quality of Service Code for HV and EHV networks. If actual results reveal that waveform characteristics are in accordance with the code values, or if they are not in accordance with the code values for reasons attributable to the client, then the client has to pay the costs related to the extra measurements. The amount that the client has to pay in this situation is limited to a figure established and published each year by the regulator (ERSE). Table 3.9 presents the amount published by ERSE for 2007.

The client can install equipment to measure the voltage quality. If the equipment is installed and sealed after a written agreement with the distribution operator, its measured values are valid as proved in a claim.

TABLE 3.9	THE MAXIMUM AMOUNT PAID BY INDIVIDUAL CUSTOMERS IN PORTUGAL DUE TO VOLTAGE QUALITY VERIFICATIONS WHEN MEASURED VALUES COMPLY WITH THE CORRESPONDING STANDARD
Client (voltage level)	**Amount (€)***
LV (N) (low voltage with contract power up to 41,4 kVA)	20
LV (S) (low voltage with contract power higher than 41,4 kVA)	176
MV	1,560
HV	5,253
EHV	5,253

These values are published by ERSE for 2007.

In Norway, upon a customer complaint the network companies are obliged to carry out the necessary investigation and measurements in order to detect whether the regulations are being violated or not, and if so, to detect the cause of the violation. Necessary measurements may include power frequency, slow voltage variations, voltage dips and swells, rapid voltage changes, flicker, voltage unbalance, harmonics and transient over-voltages. Costs related to such measurements shall be paid by the companies. Upon request from a customer with no present problem related to voltage quality, the companies are obliged to carry out measurements as requested (all VQ parameters). In latter cases, the companies may transfer the costs involved to the customer who requested the measurements.

As for individual voltage quality measurement, one case deserves special attention. In France, both the Transmission System Operator (RTE) and the main distribution company (ERDF) offer their customers customised contracts with assigned voltage quality levels ("commitments" or contractual levels). If the customer claims better contractual levels than the normal ones, he can ask the operator for customised contractual levels in his contract, paying an extra charge. Customers who have customised contractual levels must have a monitoring recorder installed (it can be owned by the customers themselves or by the system operator). The existence of voltage quality contracts has led to a high diffusion of voltage quality recorders installed on the connection points of single customers: in distribution networks, about 16% of MV customers have a voltage quality recorder installed; in the transmission network, the figure is about 12% of EHV-HV customers.

3.5.3 Market mechanisms for improving voltage quality

In some countries, the customers can negotiate with the distributor to get a higher level of quality (both voltage quality and continuity of supply); this is generally called a "power quality contract". In most cases, this is possible through the connection contracts: for example, it may involve having a dual connection with automatic changeover.

Power quality contracts are rarely monitored by the regulator. In the majority of the cases where contracts are foreseen, the regulator has no role in market mechanisms for quality, as presented in Table 3.10. "Interruptible" contracts, more widespread than power quality contracts, are not considered.

TABLE 3.10 POWER QUALITY CONTRACTS

Regulatory framework for power quality contracts	Country
Power quality contracts with some ex-ante intervention of Regulator	FR, IT
Power quality contracts with only ex-post intervention of Regulator	SI
Power quality contracts with no intervention of Regulator	CZ, DE, ES, UK, LV, PT, RO

The regulator has a specific role ex-ante in the setting of power quality contracts in only two cases.

- In France, both the transmission and distribution companies offer all customers the possibility to contract for extra quality requirements. If the customer needs better standards than the normal ones in the contract, it can ask for customised contractual levels from the operator. The customer will have to pay for them, depending on the necessary works to reach these new standards. The regulator has to receive a copy of every new contract. Even if it has no real power, the regulator has a great influence on contract models. The regulator's comments on those models are usually taken into account by the operator. When a customer wants customised contractual levels in the contract, the operator makes a technical and financial proposal, which describes the necessary works on the network to reach the levels of quality wanted by the customer, and the related costs. If the customer accepts, the works will be at the customer's expense. With customised contractual levels, the operator has to provide an annual or biannual report to the customer describing the quality performance of the site. The report should especially focus on the customised contractual levels. This situation, which existed before the regulator was established, has led to a wide usage of power quality contracts in France: in MV networks, in 2003, around 1,000 MV customers (out of more than 100,000) had customised contractual levels for continuity of supply (maximum number of unplanned interruptions per year), and 92 customers had customised contractual levels on voltage quality (voltage dips or other voltage disturbances). Moreover, around 12% of the customers directly connected to the transmission network have customised contractual levels (see also Additional information A 3.3).

- In Italy, the regulator (AEEG) explicitly provides power quality contracts and sets some minimum criteria for these. Each power quality contract must contain at least three elements: contractual level of quality, yearly premium, and penalty for non-compliance. Exclusions are possible if agreed by the parties. AEEG deemed it preferable not to require power quality contracts be submitted for preliminary approval and to limit regulatory activity to establishing a few general rules to be observed by the distribution company in offering power quality contracts: (i) the contractual level of quality shall be expressed as a threshold applied to one or more indicators of continuity of supply or voltage quality; (ii) the duration of the contract may be no less than 1 year and no more than 4 years; (iii) contracts can be differentiated according to the level of voltage and every other electrical parameter relating to supply, including the actual level of quality recorded at the delivery point. Contracts are totally voluntary, both for customers and for distribution companies (or the transmission system operator). For the system operators, the additional revenues coming from power quality contracts are treated as a service excluded from the company's revenue control. Suppliers can be involved, especially to "federate" more than one consumer interested in quality improvement in the same distribution area; the cost (and the benefits) of power quality contracts can be shared among several customers. Beyond the ex-ante criteria, distribution companies are supposed to communicate to the regulator the number and contents of power quality contracts. The rules for power quality contracts were issued in 2004 and no such contracts have been signed so far (2008).

Power quality contracts are still at a starting phase but they can be seen as an efficient solution for improving voltage quality without imposing excessive costs on general tariffs. Anyway, these contracts require that customers requiring better voltage quality have a clear willingness to pay for it. Still, minimum quality levels have to be achieved for all customers regardless of such contracts.

Additional information A 3.3 - Customised voltage dip arrangements in France

Voltage quality standards defined in the EN 50160 document are respected in France for distribution networks, even if this norm is not obligatory. Moreover, distribution and transmission grid access contracts contain voltage quality commitments (arranged contractual levels). These commitments are more demanding than standards set in EN 50160 and concern supply voltage variations, power frequency, voltage swells and transient overvoltages and voltage unbalance. They concern only customers connected to distribution networks at MV level and to the transmission network. For LV customers, such contractual conditions are not yet established.

Currently, customers connected to distribution networks at MV level or to the transmission network can ask for customised commitments on the maximum number of voltage dips they might suffer per year.

At transmission level (63 kV and above), the arrangement is 5 voltage dips per year. Only voltage dips deeper than 30% and longer than 600 ms are counted by the operator. It does not take into account voltage dips occurring less than 1 second after an interruption (short or long). Voltage dips due to a fault in the customer's installation are likewise not taken into account. If the site is supplied in 225 kV or 400 kV networks, only the duration of the fault elimination is counted as a voltage dip when the origin of the voltage dip is a fault on one phase of the main feeder. In this case, the automatic reclosure operating time (single phase operation of circuit breakers) is not taken into account.

At MV level, this commitment is determined depending on the local conditions of the site's alimentation. Since the commitment at transmission level is automatically 5 voltage dips per year, the distribution operator can not take a better one. Thus, a customer connected at MV level can not have a commitment of less than 5 voltage dips per year. As is the case for transmission, only voltage dips deeper than 30% and longer than 600 ms are taken into account by the operator.

At transmission level, the customer can ask the operator for other customised arrangements concerning voltage quality. The operator answers such requests with either a motivated rejection, or a technical and financial proposal. If the customer accepts this proposal, the cost of the necessary studies and works on the network are at the customer's expense. When customers ask for customised arrangements, they pay an annual fee to operators.

3.5.4 NRAs' requirements or recommendations about the use of VQ monitoring devices

Only a few countries have introduced requirements or recommendations for the use of voltage quality monitoring devices. In all cases, they refer to the monitoring device itself and not to current or voltage transducers that are used when the measurements are performed at voltage levels higher than LV.

In Belgium, the Technical grid code for Distribution of Electricity specifies the minimum performance in terms of accuracy of the devices.

In Italy, customers can install a voltage quality monitoring instrument, or require it from the DSOs. The instrument must be compliant with IEC 61000-4-30[14]; however no particular measurement class is required. Even class B is considered enough if properly specified.

In the Netherlands, the instruments must comply with the IEC 61000-4-30. The DSOs (LV and MV) bought new instruments in 2008 which comply with class A in IEC 61000-4-30.

In Norway, measurements of quality of supply shall be carried out in accordance with the relevant standards prepared by IEC or CENELEC. The instruments used shall be calibrated in accordance with the instrument suppliers' specifications with respect to frequency and methodology. The calibration traceability for the individual measurement parameters shall be documented. The precision and limitations of the measuring equipment shall be stated in the documentation of the measurement results. The measurement results plus uncertainties shall be within the limits specified in the regulations.

In Portugal, the Quality of Service Code established that the monitoring instruments must be of class A specified in IEC 61000-4-30 to verify the fulfilment of the regulatory limits and contractual disposals and of class B for statistics purposes, for LV delivered points and for disturbances research.

14 IEC 61000-4-30:2003 Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods.

3.6 Results from Surveys done on Costs due to Poor Voltage Quality

The CEER agrees in principle that setting voltage quality (VQ) standards requires a correct balance between the different perspectives assumed by customers, system operators and manufacturers of electrical appliances. The CEER notes, however, that the consumers' views are not adequately represented in the CENELEC TC8X WG1 work for revising EN 50160. This can ultimately lead to prejudicial underestimation of the benefits of revising power quality norms and overestimation of costs that might be incurred because of new norms.

Similarly, In the ERGEG Conclusions Paper "Towards Voltage Quality Regulation in Europe" (July 2007), European energy regulators expressed concern about the underestimation of benefits of changes in voltage quality standards given by EN 50160, due to non-active participation of an important class of policy actors: customers' associations. Some parties who contributed to the ERGEG public consultation (especially distribution operators' associations) suggested a cost/benefit analysis. ERGEG invited interested parties to provide cost and benefit elements useful for such analysis, recommending that the elements are based on evidence and facts, like for instance VQ monitoring system results, customer surveys and other technical and economical methodologies. Further, for a better understanding of the very technical issues related to VQ, collaboration with experts, from both universities and research centres, should be improved. This can be achieved also by means of a stricter cooperation with international research groups already active in the subject (e.g. CIGRE and CIRED study committees).

Any cost/benefit analysis to be carried out must be with reference to today's voltage quality levels and not with reference to existing limits in standards. When existing voltage quality levels are better than the limits described in standards, it will also imply costs if one allows today's level to decline towards the limits described in standards. Evaluating benefits for new limits is probably the most difficult part of the proposed cost/benefit analysis. Nonetheless, some surveys have attempted to evaluate the costs borne by customers due to poor voltage quality. Many of these surveys are publicly available: for example, recent research conducted by Leonardo Power Quality Initiative (LPQI) estimates a total cost due to poor power quality, in Europe, in excess of € 150 billion per year[15] (CIRED, 2007, paper 0263). The LPQI projection of costs at the European level is based on a limited number of observations and, of course, further research is needed.

Research projects have been conducted recently in some countries (e.g. Norway and Italy), in this direction with the commitment of the regulators or with their cooperation, in order to assess customers' costs for poor power quality, with special reference to voltage events like short and transient interruptions and voltage dips.

The CEER strongly believes in the need for conducting independent research about customers' costs resulting from poor power quality, which can be used as a basis for assessing the benefits of new limits. Priority should be given to voltage events like dips and swells. In this perspective, European energy regulators think that CIRED and CIGRE's efforts in this direction should be encouraged as a pre-normative research phase. In particular, some regulators have already shared with CIGRE-CIRED JWG C4.107 "Economic Framework for Power Quality" the results of the studies that they have commissioned. Further liaison has been established with CIGRE-CIRED-UIE JWG C4.110 "Voltage dip immunity of equipment in installations". The CEER considers these joint working groups as the most appropriate places where costs and benefits can be discussed and compared.

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15 Targosz, R., Manson, J., 2007. Pan European LPQI power quality survey. In: 19th CIRED (International conference on electricity distribution) Proceedings, Vienna, Austria.

3.6.1 Norway (2002) survey on customers' costs due to interruptions and a few selected voltage disturbances

A nation-wide survey financed by the Research Council of Norway, the regulator (NVE), utilities, a utility association and large consumers was carried out in 2001 and 2002, related to customers' costs due to interruptions and a few voltage disturbances. The overall aim was to obtain better knowledge of customers' costs related to these phenomena in order to aim at a socially efficient operation, expansion and development of the power system. The survey provided cost estimates that have been included in the regulation on continuity of supply.

The survey was directed at all kinds of customers, aggregated into 6 different customer groups:

- Industrial
- Trade and service
- Agricultural
- Residential
- Public service
- Wood processing and energy-intensive industries

Norwegian customers' costs related to short and long interruptions have been estimated to be of the order of 4-500 MNOK and 5-600 MNOK respectively annually.

Regarding voltage disturbances, the survey was limited to voltage dips with 50% residual voltage with 1 second duration for the entire above customer categories, except for the residential group. Results are presented in Table 3.11.

TABLE 3.11 NORWAY, SURVEY (2002) RESULTS: NORMALISED COSTS (DIRECT WORTH ESTIMATE) ON VOLTAGE DIPS (50% RESIDUAL VOLTAGE, 1 SECOND DURATION), COST LEVEL 2002[17]

Customer group	N	Normalised cost NOK/kW	Standard deviation NOK/kW
Industrial	123	30.4	47.1
Trade and service	128	22.1	50.5
Agricultural	83	13.6	38.9
Residential	-	-	-
Public service	86	1.6	6.8
Wood processing and energy-intensive industries	13	5.6	8.5

Norwegian customers' costs due to voltage dips have been estimated to be of the order of 170-330 MNOK annually.

Further, the processing industry, which is part of the customer group of wood processing and energy-intensive industries, was asked about various depths and durations of voltage dips, transient overvoltages and supply voltage variations. However, due to the low number of respondents and the uncertainty in the data, they are not presented here.

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16 Source: IEEE Transactions on power systems, Vol. 23, No. 3, August 2008, G. Kjølle, K. Samdal, B. Singh and O. A. Kvitastein.

3.6.2 Sweden (2003) surveys on customers' costs due to short interruptions and voltage dips

In Sweden, a research project initiated by Elforsk (Swedenergy) was finished in 2003 and estimated annual costs for industrial customers related to short interruptions and voltage dips at about € 157 M (actual costs) per year.

It must, however, be emphasised that this study has been relatively limited and that only theoretical effect analysis has been performed, as well as a small number (~ 20) of sample interviews. The normalised cost (€/kW per event) for interruptions in production varied from 0 to 110 €/kW, for material costs it varied from 0 to 25,000 €/kW and for equipment costs it varied from 0 to 130 €/kW.

Further references can be found through:

- "Elkunders störningskostnader", in Swedish, Elfork rapport nr 04:42, 2003;
- "Elöverföring av god kvalitet", in Swedish, Elforsk rapport 06:81, 2006.

The regulator did not initiate or participate in the mentioned studies.

3.6.3 Italy (2006) survey on customer costs for "micro-interruptions"

In Italy, the energy regulator (AEEG) commissioned in 2006 a research project from the Politecnico di Milano (Dep. of Management, Economics and Industrial Engineering) to estimate the costs of voltage quality for industrial users. The project had two objectives:

1. to estimate the costs of voltage disturbances at plant-level, focusing on two specific events: transient interruptions (shorter than 1 second) and voltage dips (hereafter 'micro-interruptions');
2. and to estimate the significance of these costs for the Italian economy.

More generally, the purpose of the work was to provide guidance in the current debate regarding voltage quality regulation in Italy. The Italian survey had three distinctive features:

- the precondition for an industrial user to be included in the study was the availability of a power quality recorder at the user's bus bar. This condition was essential to correctly attribute costs to the voltage events of interest (micro-interruptions) and not to other phenomena. At the same time, this condition limited the number of potential respondents. As a consequence, the observed sample is not stratified in line with the Italian economy. This does not significantly affect the results of the analysis in terms of cost indicators at plant-level; however, it weakens the robustness of the projection to the Italian economy;
- the methodology developed for the estimation of direct costs was not based on contingent valuation, but on an original instrument developed during the project start-up phase, and called the 'journal of events': the interested customers registered in the journal the actual costs[17] that were incurred due to process trips that occurred due to actual micro-interruptions;
- the journal did not request direct cost estimations from the respondents; it required the end-users to provide a structured description of 'what happened' at the production site during the voltage disturbance, together with per-unit economic data (for instance, hourly wages). Costs were calculated by the research group according to a standard procedure.[18]

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17 Poor voltage quality related costs include both economic losses experienced in the event of a micro-interruption as well as investments costs sustained for protecting the working facility. In fact, given the large installed capacity of manufacturing plants, only a percentage of the load is normally protected with UPS or similar equipment.

18 Direct costs were evaluated with reference to 3 types of costs:
1) Lost production or production recovered through overtime; 2) Wasted production, defined as work in progress that has to be discarded or recycled; 3) Replacement or repair costs for damaged equipment and devices. Indirect costs were approximated by UPS yearly depreciation and maintenance costs.

The study provided clear answers in terms of the research objectives[19]. With reference to the first objective, multiple and fine-grained direct cost indicators were derived for the industrial sectors explored. As illustrated in Table 3.12, the median (mean) of direct costs per event per kW over the entire sample is 0.8 €/kW/event (2.8 €/kW/event). The range of values goes from a minimum of 0 €/kW/event to a maximum of 30 €/kW/event. Excluding the observations with zero direct costs (due to the presence in the sample of customers that are not sensitive to micro-interruptions), the median (mean) has a value of 1.1 €/kW/event (3.3 €/kW/event). In general, significant differences in direct costs have been observed between firms in the same sector and, above all, between sectors. These differences remain quite large even when comparing normalised indicators (per kW) or costs per event (not affected by the frequency of the events). This result is explained by the wide range of production processes included in the sample. For instance, in the paper sector, the project managed to observe several plants producing tissue; in this case, results for these plants were not dissimilar. However, the paper sector included also plants producing technical papers and/or paperboard. For the latter, cost figures turned out to be quite different. Taking into account the unavoidable differences in the ways in which the surveys were conducted, the Italian survey results are in line with the figures given by the existing national and international literature. In particular, the field survey confirms the high sensitivity to micro-interruptions in the production of: food products, textiles, paper, chemicals and man-made fibres, plastic, glass, ceramic and metal products and electrical equipment, as well as auto and components.

TABLE 3.12 ITALY, SURVEY (2006) RESULTS: DIRECT COSTS DUE TO MICRO-INTERRUPTIONS- [€/KW/EVENT]

Customer category	Entire sample (sub-sample)		
	Mean	Median	Interval
Auto and auto components	2.9	2.9	0.7 – 5.0
Plastic products	2.2	1.8	0.1 – 4.2
Textiles	3.2	3.2	3.2
Paper	0.9 (1.0)	0.8 (0.9)	0.1 – 2.2
Refined petroleum products	13.3	13.3	13.3
Metal products	3.3 (4.9)	1.1 (4.9)	0 (1.1) – 8.7
Glass and ceramic products	0.9	0.8	0.1 – 2.3
Food products	5.9	0.6	0.2 – 30
Chemicals and man-made fibres	0.5 (0.7)	0.6 (0.7)	0 (0.6) – 0.8
Electrical equipment	10.6	9.3	0.1 – 22.4
All sectors	2.8 (3.3)	0.8 (1.1)	0 (0.1) - 30

The figures in brackets exclude observations with 0 values

As far as the second objective is concerned, the study estimated the total (direct and indirect) annual costs of voltage quality for the national economy, within a lower and an upper bound.

For the lower bound, the study assumed that direct costs are sustained only by the Observed Sensitive Sectors (OSS). These are the sectors, among those classified as sensitive by experts and in the literature, for which at least one completed questionnaire was available.

19 Fumagalli, E., Garrone, P., Grilli, L., Redondi, R., 2007. Service quality in electricity supply: the customer's costs. In: P. Garrone (editor), "Investments and service quality in the electricity industry", Milano, Franco Angeli (2007). A second paper was submitted for consideration to IEEE Transactions on Power Delivery.

- Median value of the total annual costs for the whole Italian production system: 464.6 M €/year (with the inclusion of nation-wide annual indirect costs, estimated to be approximately 196.8 M €/year).

The upper bound was estimated assuming that direct costs are sustained also by Unobserved Sensitive Sectors. These sectors were labelled as sensitive by experts and by the literature. Nonetheless, no completed questionnaires were available for any of them.

- Median value of the total, annual costs for the whole Italian production system: 780.2 M €/year (with the inclusion of nation-wide annual indirect costs).

The conclusions can be summarised in three points:

First, direct costs caused by micro-interruptions are highly concentrated. Taking the median values of the lower and upper bound estimations, the study finds that, for every € 1,000 of sales (added-value), a generic Italian firm sustains a total annual cost for micro-interruptions that is comprised between 0.20 €/year (0.81 €/year) and 0.34 €/year (1.36 €/year). By contrast, the study estimated that for every € 1,000 of sales (added-value) a firm in the OSS experiences a direct cost of 1.5 €/year. These costs are more than four times higher than those borne by firms in a generic sector. In other words, direct costs are significant for the industrial sectors that experience them; however, these sectors represent a small portion of the whole Italian economy (16.97% in terms of sales).

Second, the study also found that indirect costs due to investments in protection equipment (197 M €/year) are significant (the median value of the direct costs for OSS is 268 M €/year) and, more importantly, that they are rather diffused in many sectors of the Italian production system (not only OSS).

Third, this analysis highlighted that the average Italian firm is unlikely to suffer significant costs because of micro-interruptions. At the same time, it is possible to assert that a small but non-negligible number of production units bear a considerable amount of costs due to the phenomenon.

3.6.4 Further research on customer costs due to poor voltage quality and development of power quality contracts

Several European countries have estimated customers' costs related to short and long interruptions over the past years and decades. A large consensus exists regarding the methodology for assessing customer costs for long interruptions[20] and the available empirical work is rich in applications[21]. On the contrary, the economics of voltage quality is not yet a consolidated subject.

When voltage quality has been included in customer surveys, in general only the costs of a few voltage disturbances have been investigated. Consistent with the fact that the most dangerous voltage disturbances are voltage events, available surveys focus on voltage dips and interruptions. Even the

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20 CIGRE (2001), Methods to consider customer interruption costs in power system analysis, Technical Report, Task force 38.06.01.

21 The following papers describe the application of customer cost surveys for interruptions: for Italy, Bertazzi A., Fumagalli E., Lo Schiavo L. (2005), "The use of customer outage cost surveys in policy decision-making: the Italian experience in regulating quality of electricity supply" in: 18th CIRED (International conference on electricity distribution), Turin, Italy, June 2005; for Norway, Samdal K., Kjolle G., Singh B., Trengereid F. (2003), "Customers' interruption costs: what's the problem?" in: 17th CIRED (International conference on electricity distribution), Barcelona, Spain, June 2003; for the United Kingdom, Ofgem (2004), "Electricity distribution price control review - Appendix - Consumer expectations of DSOs and WTP for improvements in service report", Consultation document 145f/04, available from: www.ofgem.gov.uk; for Sweden: Carlsson F., Martinsson P. (2005), "Willingness to pay among Swedish households to avoid power outages", Elforsk rapport 05:04, available from: www.elforsk.se.

identification of sensitive users is not straightforward. Several factors need to be considered: endogenous factors, such as the type of equipment and the production process, and external factors, such as the design of the distribution network, and the environment.

Economic indicators are extremely important elements of a regulatory decision, in particular when, as in this case, the decision concerns a new area, where the instruments of regulation have not yet been employed. Specifically, economic measures may indicate whether or not regulatory intervention is necessary for the scope of customer protection and, if regulatory action is deemed necessary, they may indicate what types of instruments are best suited for the scope. Given the distribution of customers affected by some VQ disturbances (like for instance micro-interruptions), a regulatory measure that is designed for the protection of all consumers from voltage disturbances might not be the only possible solution. The results of available studies seem to indicate that 'individual' regulatory instruments, like power quality contracts, might be another reasonable choice.

Power quality contracts are still at a starting phase but they can be useful for revealing customer preferences for quality, especially for customers with the greatest need for continuity of supply and voltage quality. These contracts require that customers needing better voltage quality have a clear willingness to pay for it. This does not mean that regulators should not provide incentives and minimum requirements to companies for improving the VQ of their networks, as far as reasonable benefits are achievable; see also section 3.5.3.

3.7 Actual Voltage Quality Monitoring Systems and Data

Over the years, a growing number of European countries have commissioned monitoring systems which are currently in operation. Systems have been quite different since the conception phase as no harmonisation requirements have been introduced by regulators and in some cases the initiative to put into operation monitoring systems has been taken autonomously by operators. Furthermore, reasons that push the implementation of these systems vary from country to country. This has led to different choices with respect to:

- voltage levels involved in the monitoring;
- type of network to be monitored;
- number and percentage of network points to be monitored and criteria of selection of network points under monitoring;
- voltage quality disturbances to be monitored; and
- type of monitoring: continuous, rolling, etc.

As a consequence, voltage quality data suffers as well from this lack of harmonisation, both in terms of classification and aggregation criteria. Finally, the publication of voltage quality data doesn't fulfil common rules and so the way in which data is published, if any, differs from country to country.

3.7.1 Voltage quality monitoring systems in operation

There are systems in operation in 11 countries. The following table summarises the countries where systems are running, the period of monitoring and the number of monitoring units, differentiated per voltage level. Additional information about criteria adopted from Belgium, France, Italy and the Netherlands for the selection of monitoring sites is reported below in Additional information A 3.4.

TABLE 3.13	MONITORING SYSTEMS IN OPERATION: NUMBER OF MEASURING UNITS AT DIFFERENT VOLTAGE LEVELS				
Country	**Period of monitoring**	**Number of measuring units installed**			
		EHV and HV	**MV**	**LV**	**total**
Belgium Federal	Not available	223	5	0	228
Belgium Flemish		nd	nd	nd	nd
Belgium Wallonia		0	137	0	137
Belgium Brussels		-	-	-	-
Czech Republic	Transfer points TS/DS since 1/1/2006 Delivery points 110 kV since 1/1/2007	20 at 220/110 kV 42 at 400/110 kV			62
Denmark	Since 2007		8		
France	Since 1995	636 (of which 3% in MV)	About 30,000		About 30,636
Greece	Since 2008			500	500
Hungary	Since 2003			400	400
Italy	MV since February 2006 HV and EHV since January 2007	165	600		765
Luxembourg	Depends on system operator as previously (prior to new electricity act) not mandatory.		nd	nd	nd
the Netherlands	Since 2004 (EHV and HV) Since 1996 (for all DSOs)	8 (220-380 kV) 20 (50-150 kV)	60 (1)	60 (1)	148 (1)
Norway	Since 2006 (2)	nd (2)	nd (2)	(2)	nd (2)
Portugal	2006 (3)	64	90	131	285

(1) Several monitoring instruments to perform yearly at least 60 measurements of 1 week each at both the MV and LV network.
(2) In Norway, a previous voluntary monitoring campaign was also carried out 1993-2003; see Annex 3 for more information.
(3) In Portugal, the number of units has been increasing since 1999; the first year that ERSE received information about voltage quality characteristics.
nd Not declared - it means that there are instruments working, but it is not known how many there are.

In Belgium; the figures in Table 3.13 correspond to: 228 units working (April 2008) on EHV and HV systems operated by the TSO (ELIA), and 137 units installed on the MV side of HV/MV substations operated by DSO in the Walloon region. Continuous monitoring is performed at EHV and HV. At MV, either continuous or rolling monitoring is performed.

Below are the start dates from which there was continuous monitoring of voltage quality in the Czech Republic for different kinds of points. The list proceeds from the Czech Distribution Grid Code.

- Transfer points TS/DS — continuously monitored (since 1/1/2006)
- Delivery points 110 kV — continuously monitored (since 1/1/2007)[22]
- Substations output voltage 110 kV/MV — continuously monitored (since 1/1/2010)[23]
- Delivery points MV — selection[24]
- Substations output voltage MV/LV — selection[24]
- Delivery points LV — selection[24]

22 As for delivery points 110 kV, these parameters are monitored and archived from 1 January 2007 if recognised values of some of the guaranteed parameters exceed 50% of limit values for the given delivery point during the preliminary weekly monitoring (repeated every 2 years). The permanent installation can be avoided if the distribution system operator is able to document level of these characteristics by way of measured values of neighboring delivery points or transfer points of transmission/distribution system.

23 As substations output voltage are monitored and archived since 1-1-2008 if recognised values of some of guaranteed parameters exceed 50% of limit values for the given point during the preliminary weekly monitoring (repeated every 2 years).

24 Delivery points MV are monitored in cases of litigations, claims for connection of users with sensitive technologies or according to the experiences of the DSO.

In Denmark, there is a small system running in a large city, installed in March 2007, that consists of 8 measurement units (3 at 30 kV and 5 at 10 kV). Measurements are performed according to EN 50160 and with instruments according to IEC 61000-4-30, class A performance. The system was autonomously installed by the DSO for statistical and research purposes, in a joint project with the Danish Energy Association. The 10 kV measurement sites were chosen on the basis of the supplied load type (IT industry, residential areas, supply of electrical trains). Furthermore, under normal operating conditions, the selected 30 kV sites supply the selected 10 kV sites.

In France, measuring units in EHV and HV networks are mostly located next to customers' delivery points. The TSO (RTE - Gestionnaire du Réseau de Transport d'Electricité) intends to ensure redundancy of measurements on each system so a few other network points are equipped. Most of the systems are operated at fixed (stationary) point of the network. If necessary (i.e. upon a customer complaint), provisional systems can be implemented. Concerning MV customers (around 30,000), about 30% of them are equipped with a remote metering device (especially customers with subscribed power > 250 kVA).

In Greece, a monitoring programme was launched in late 2007 consisting of 500 power quality analysers. The installation was completed in February 2008 and data recording was initiated for each of the 500 points at the time of installation. Out of the 500 instruments; 120 are connected to 3-phase LV lines and 380 to LV single phase lines.

In Hungary, customer connection points are chosen randomly and monitored over a period of 6 months. After that period, the measuring units are installed at other points chosen with the same criterion.

In Italy, continuous monitoring is running in MV networks (from 6.6 kV up to 30 kV, typically 20 kV) and in transmission and HV distribution networks (380kV, 220kV, 150kV, 132kV, 60kV).

In Norway[25], all voltage levels above 1 kV are involved in continuous monitoring. New quality of supply regulation required monitoring systems to be in operation from 1st January 2006. Every network company is obliged to continuously carry out monitoring on characteristic areas of their MV, HV and EHV network. Important elements to consider when dividing the network into different characteristic areas are inter alia underground cables versus aerial lines, system earthing, extension of the network, customer categories connected, climatic differences, short circuit power, etc. The companies must decide by themselves how many instruments are necessary in order to create trustworthy statistics. Each network company must have at least one instrument installed in each different characteristic area.

In Portugal, data reported in Table 3.13 refers to the monitoring system that exists on the mainland. 2 other similar systems are working in the Archipelagos of Açores and Madeira. In principle, the 3 monitoring systems are identical but adapted to the reality of each region (basically, some standard values applied are different). The quality of survey codes in force in each region are basically the same except for frequency limits. The data reported in the table above is related to the main distribution company (that distributes 99.5% of the electrical energy) and to the transmission system operator. The quality of service code establishes that every transmission network delivered point in the HV and EHV must be monitored within a period of 2 years. The same code establishes that, in a period of 4 years, monitoring must be carried out on the voltage quality in all HV/MV

25 Please note that the current monitoring scheme laid down in the regulation on quality of supply is somewhat different from the previous voluntary monitoring scheme carried out from 1993 to 2003. Actual voltage quality data presented in this report from Norway is only with basis in the previous monitoring scheme. The regulator (NVE) has, as yet, no data available from the current monitoring scheme. Please find further information in section 3.7 and in Annex 3.

substations (in MV bus bar) and at least 2 power transformer stations of each municipality (in LV), in a distribution network. The monitoring duration in each point must be in accordance with the standards in force.

Additional information A 3.4 - Selection of monitoring sites

Belgium:

The number of running monitoring devices operated by the TSO is shown in the following table for each voltage level.

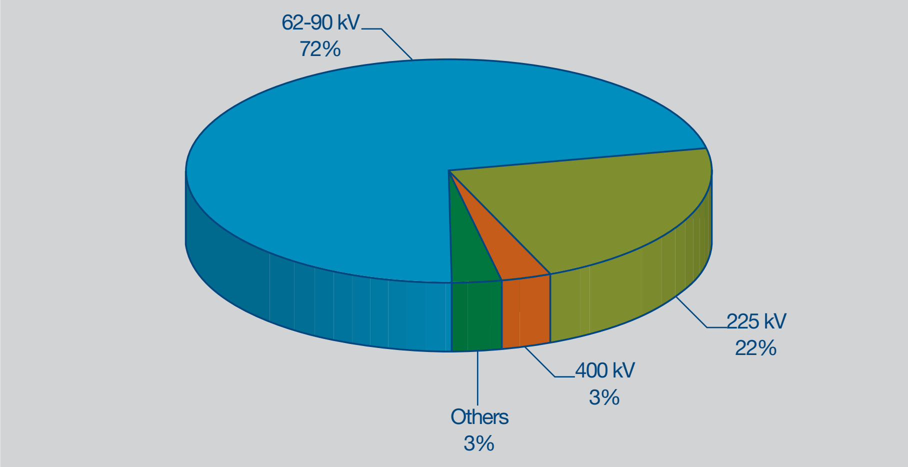
TABLE 3.14 BELGIUM: NUMBER OF MONITORING DEVICES OPERATED BY THE TSO

Voltage level	Number of monitoring devices
30 kV	5
36 kV	52
70 kV	65
150 kV	87
220 kV	11
380 kV	8
Total	228

France:

The following figure shows the way the 636 monitoring units are divided (in percentage) among the different voltage levels of EHV and HV networks.

FIGURE 3.2 VOLTAGE LEVELS, TO WHICH VOLTAGE QUALITY MONITORING UNITS ARE CONNECTED IN FRANCE.



Others (3%) are at 45 or 42 kV (former network voltage) or at secondary (20 or 15 kV) of some HV/MV transformers (none at LV).

Italy:

MV network monitoring system:

In Italy, the MV distribution network is characterised by the following figures:

- Around 1,800 HV/MV substations that normally have two MV bus-bars. Under normal operation, bus-bars are separated and each one is fed through a HV/MV transformer. The total number of MV bus-bars is around 3,700. They feed only networks that are radially operated.
- Around 360,000 km of lines at rated voltage 10 kV, 15 kV or 20 kV. 40% of the lines are underground cables while 60% are aerial with bare conductors.

The system feeds approximately 330,000 MV/LV substations; 100,000 of them are dedicated to MV customers. 140,000 pole mounted MV/LV transformers are installed for rural LV distribution. A total of 600 measuring units were installed in different sites of the MV networks chosen with the criteria described below. Around 400 MV bus-bars in HV/MV substations (corresponding to 11% of the MV networks) chosen to statistically represent as far as possible the complete Italian territory and its environmental conditions. In each region, the MV networks were chosen to be statistically representative of the following parameters that were judged as the most relevant from the VQ point of view:

- total length of the lines connected to the MV bus-bar;
- type of MV lines (aerial with bare conductors, cable, mixed);
- type of neutral operation of the MV network (isolated neutral, compensated neutral);
- number of MV customers;
- density, per square kilometre, of LV customers fed by the MV network.

Around 200 MV PCCs along the MV lines freely chosen by MV customers (around 70 installations) and by DSOs (around 130 installations), giving priority to the options of the customers. These 200 points do not form a statistically representative sample; however they are useful at system level for comparing measurements in the bus bars with measurements in the PCC.

EHV and HV networks monitoring system:
In Italy, there are voltage levels that belong partly to the transmission and partly to the distribution: this happens for 220 kV, 150 kV and 132 kV. 380 kV belongs entirely to the transmission, 60 kV belongs entirely to the distribution.
107 monitoring devices are installed on a sample of HV bus-bars of EHV/HV stations of the TSO (Terna), with the main objective to monitor around the 20% (about 100) of the total number of HV bus-bars of the Transmission network, all over the Italian territory. Criteria taken into account for the selection of the bus-bars were:

- short circuit power on the bus-bar;
- power of the EHV/HV transformer;
- type of network fed by the Station;
- type of loads and of generators.

A further 58 monitoring devices were installed on HV distribution networks. In the following table the total number of monitoring devices that are currently monitoring the Transmission and the HV distribution network are shown:

TABLE 3.15 ITALY: NUMBER OF SITES MONITORED IN EHV AND HV NETWORKS

Voltage level	Transmission	HV Distribution	Total
380 kV	7	0	7
220 kV	10	6	16
150 kV	23	23	46
132 kV	67	27	94
60 kV	0	2	2
Total	107	58	165

the Netherlands:
In the Netherlands, from the start of the monitoring scheme the selection of network points under monitoring (1 week) was based on a random selection of ZIP-codes. As from 2004, all customer connection points in the EHV network are monitored, and at the HV network; 20 customer connection points are randomly selected to monitor the voltage quality continuously. As from 2008, the random selection of 60 network customer connection points at both the MV and LV is based on EAN-codes instead of ZIP-codes.

Voltage disturbances monitored in the different countries are presented in Table 3.16.

TABLE 3.16 VOLTAGE DISTURBANCES CURRENTLY CONTINUOUSLY MONITORED IN DIFFERENT EUROPEAN COUNTRIES

Voltage disturbance	Belgium	Czech Republic	France	Greece	Hungary	Italy	the Netherlands	Norway	Portugal
Power frequency (1)	HV	HV	EHV, HV	LV		EHV, HV			All
Supply voltage variations	HV, MV	HV	EHV, HV, MV	LV	LV	EHV, HV, MV	All		All
Single rapid voltage changes		HV		LV		EHV, HV, MV	All	EHV, HV, MV	
Flicker	HV, MV	HV	EHV, HV	LV		EHV, HV, MV	All		All
Voltage unbalance	HV	HV	EHV, HV	LV	LV	EHV, HV, MV	All		All
Harmonic voltages	HV, MV	HV	EHV, HV	LV	LV	EHV, HV, MV	All		All
Voltage dips	HV	HV	EHV, HV, MV	LV	LV	EHV, HV, MV		EHV, HV, MV	All
Voltage swells	HV	HV	MV	LV	LV	EHV, HV, MV		EHV, HV, MV	
Transient overvoltages		HV		LV					
Interharmonic voltages		HV		LV					
Mains signalling voltages		HV		LV					

(1) In all countries, the power frequency is monitored and managed by the interconnected European transmission system operators and international system operation agreements. This table only refers to what is monitored by voltage quality instruments in place for continuous monitoring.

In France, two generations of measuring instruments are present. The "first generation" measuring instruments were installed since 1995 and the "new generation" instruments with 161 units that were commissioned in 2006. Only the "new generation" includes also frequency and flicker.

The following table shows the institution that promoted the initiative for the monitoring scheme, e.g. Regulatory Authority, Ministry, TSOs or DSOs. The purposes for monitoring are also reported.

TABLE 3.17 INITIATIVES FOR VQ MONITORING AND PURPOSES (WHEN NOT DUE TO COMPLAINTS)

Country	Initiative	Purposes
Belgium HV	TSO	Provide measurements to HV customers sensitive to voltage dips, in case of incidents. Monitor the VQ in substation where disturbing grid users are connected (producing flicker, harmonics or voltage unbalance).
Belgium MV - Flemish region - Brussels region - Wallon region	DSO	- Regulation - Statistics and regulation - Statistics
Czech Republic	TSOs and DSOs	Archiving, statistics, planning of development of distribution systems, research
Denmark	DSO	Statistics and research
Greece	Regulator	Obtain a sample of reliable data on all voltage characteristics of EN 50160, in order to gain a rough idea of the existing supply quality level. Results are to be considered in setting parameters of a quality regulation scheme.
France	TSO and DSOs	Analyse disturbances related to the contractual commitments or provide information on quality level expected.Statistics
Hungary	Regulator	Statistics and research
Italy	Regulator	Regulation and statistics (see below)
Lithuania	TSOs and DSOs	Network management and monitoring
Luxembourg	TSOs and DSOs	Network management and monitoring
the Netherlands	TSOs and DSOs	Regulation and statistics
Norway	Regulator	Regulation and statistics
Portugal	Quality and Service Code issued by General Directorate of Energy and Geology	Regulation and statistics

In Italy, monitoring on MV networks has the following objectives:

- knowledge of the performances of the MV distribution networks;
- correlation of the measured VQ parameters to the type of the networks;
- promotion of individual measurements and VQ contracts through a voluntary participation of customers in the campaign;
- verify the possibility of introducing measurement obligations for DSOs and then financial regulation of some VQ indicators;
- confirm or revise limit values of VQ indicators so that they can reflect the characteristics of the Italian electrical system.

Monitoring of transmission and HV distribution networks is performed in order to verify the possibility of introducing financial regulation of some VQ indicators.

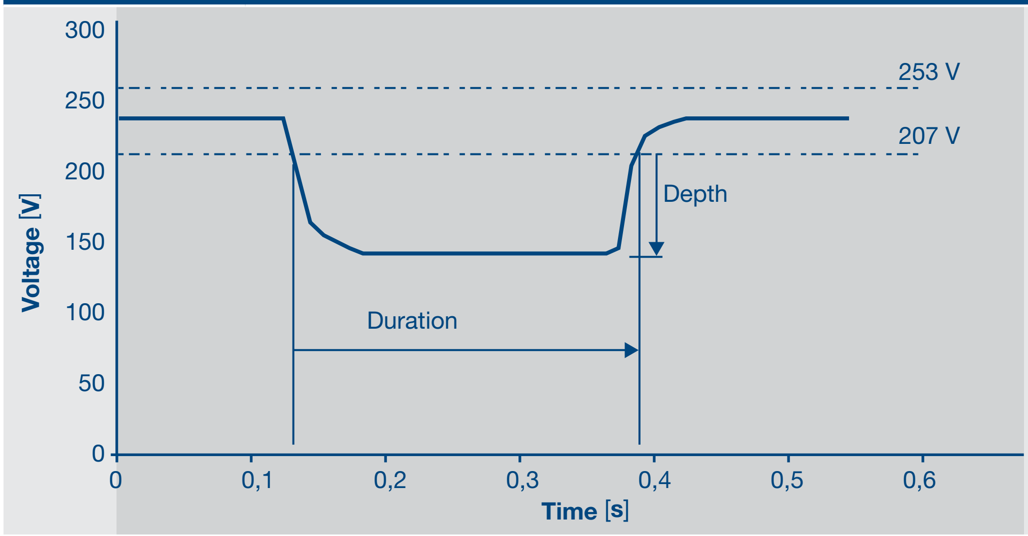
In Portugal, since the publication of a new Quality of Service Code in 2006, the verification of the voltage waveform must be done with the objective of characterising the quality of the entire grid and identifying zones that require an improvement of its quality.

3.7.2 Data available from voltage quality monitoring systems in operation

In this section, data reported by 6 countries (France, Hungary, Italy, the Netherlands, Norway[26] and Portugal) is presented. Only data for voltage dips has been included below; additional data concerning other voltage disturbances is reported in the Annex.

A voltage dip can be defined as a temporary reduction of the voltage magnitude at a point in the electrical system below a threshold, c.f. IEC 61000-4-30. The figure below shows a typical voltage change characteristic during a voltage dip.

FIGURE 3.3 TYPICAL VOLTAGE CHANGE CHARACTERISTIC DURING A VOLTAGE DIP



Due to the already mentioned lack of harmonisation between countries regarding monitoring of voltage quality, the data on voltage dips are only partly comparable both for residual voltage and duration. And indeed voltage dips have been classified in different ways:

- In France, a voltage dip is defined as a sudden drop of supply voltage (U_f) to a value between 90% and 1% of the contracted voltage (U_c), followed by the restoration of voltage after a short period of time. A voltage dip can last 10 milliseconds to 3 minutes. TSOs' commitment takes the form of thresholds according to the same principles as for interruptions of supplies, and the voltage dip is characterised by its depth and duration. The TSO undertakes for a voltage dip whose depth is greater than 30% of U_c (ripple < 0.7 U_c) for a period of more than 600 msec. The commitments of a DSO are the same as that of a TSO.
- Hungary has adopted the definition given in EN 50160 and developed their own classification table.
- Italy reported dips related to MV bus-bars in HV/MV substations according to the new classification table proposed in prEN 50160:2008.[27] and dips related to the EHV and HV networks monitoring system according to the UNIPEDE[28] classification;
- the Netherlands reported dips according to the classification developed by UNIPEDE.

26 The data from Norway refers to the previous voluntary monitoring campaign (1993-2003) and do not include data from the current monitoring scheme. The statistics were produced in 2004.
27 Voltage dips related to MV bus-bars in HV/MV substations currently reported by the QUEEN web site are classified according to the UNIPEDE table.
28 UNIPEDE = International Union of Producers and Distributors of Electrical Energy.

- Norway reported dips from the previous voluntary monitoring campaign based on the definition of a voltage dip given in EN 50160 and the tabulation developed by UNIPEDE with reference to IEC 61000-2-8[29], see also footnote[27]. Regarding the current scheme, voltage dips are defined in the Norwegian regulation on quality of supply, and it is planned to do classification according to the classification tables presented in the new draft EN 50160.
- Portugal reported dips based on the definition given in EN 50160 and the classification of tables presented in IEC 61000-2-8.

France

The 246 delivery points referred to in Table 3.18 correspond to: 199 industrial customers connected at 63 or 90 kV; 46 industrial customers connected at 225 kV; 1 industrial customer connected at 400 kV.

TABLE 3.18 FRANCE: AVERAGE NUMBER OF VOLTAGE DIPS DURING 2007 AMONG 246 DELIVERY POINTS OF HV INDUSTRIAL CUSTOMERS (A TOTAL OF 9,089 VOLTAGE DIPS)

Residual voltage u	Duration t (ms)		
(%)	20 < t ≤ 200	200 < t ≤ 500	500 < t
90 > u ≥ 80	23.6	1.1	0.4
80 > u ≥ 70	6.2	0.2	0.2
70 > u ≥ 40	4.0	0.2	0.3
40 > u ≥ 8	0.5	0.1	0.1

Hungary

TABLE 3.19 HUNGARY: AVERAGE NUMBER OF VOLTAGE DIPS IN 6 MONTHS DURING 2005-2007 AMONG 2,400 DELIVERY POINTS OF THE LV NETWORK

Residual voltage u	Duration t (ms)						
(%)	20 < t ≤ 120	120 < t ≤ 200	200 < t ≤ 1,000	1,000 < t ≤ 2,000	2,000 < t ≤ 5,000	5,000 < t ≤ 10,000	10,000 < t ≤ 60,000
90> u ≥ 70	469.44	184.13	41.02	78.04	17.77	13.13	6.37
70> u ≥ 40	6.78	8.32	3.28	1.81	0.29	0.18	0.15
40> u ≥ 20	3.44	2.80	0.85	0.86	0.13	0.21	0.08
20> u ≥ 10	2.67	1.64	0.20	0.30	0.07	0.06	0.04
10 > u	0.78	1.52	0.64	2.33	3.90	1.16	0.48

Italy (voltage dips related to EHV and HV networks monitoring system) - Tables 3.20 and 3.21

Data reported in the following two tables:

- refer to the period 01/01/2007 - 30/12/2007 (52 continuous weeks);
- refer to the entire Italian network at 380 kV-220 kV and at 150 kV-132 kV;
- are compliant with EN 50160 and EN 61000-4-30;
- refer to the aggregation of the total number of monitoring points, which is 23 for 380 kV-220 kV network and 138 for 150 kV-132 kV network;
- refer to the total number of the equivalent monitoring points (due to more than one reason, for some monitoring points, VQ data in some weeks are not available) in the considered period (01/01/2007-30/12/2007), which is 21.2 for 380 kV-220 kV network and 131 for 150 kV-132 kV network.

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29 IEC TR 61000-2-8: Electromagnetic compatibility (EMC) - Environment - Voltage dips and short interruptions on public electric power supply systems with statistical measurement results.

Italy (voltage dips related to MV bus-bars in HV/MV substations) - Table 3.22
Data reported in the following table:

- refer to the period 01/01/2007 - 30/12/2007 (52 continuous weeks);
- refer to the entire Italian territory, to all type of networks (cable, aerial, mixed), to both type of neutral operation (isolated, grounded through impedance), and include different distribution networks for extension, nominal voltage level, installed power of HV/MV transformers;
- are compliant with EN 50160 and EN 61000-4-30;
- refer to the aggregation of the total number of monitoring points, which is 404;
- refer to a total number of the equivalent monitoring points (see above), which is 369.9.

TABLE 3.20 ITALY: VOLTAGE DIPS RELATED TO 380 KV - 220 KV NETWORK MONITORING SYSTEM (AVERAGE NUMBER OF VOLTAGE DIPS PER POINT, PER YEAR, ACCORDING TO THE UNIPEDE CLASSIFICATION)

Residual voltage u	Duration t (ms)					
(%)	20 < t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 60,000	Total
90 > u ≥ 85	19.0	1.5	0.1	0.0	0.0	20.6
85 > u ≥ 70	24.2	3.5	0.3	0.0	0.0	28.0
70 > u ≥ 30	13.6	2.4	0.6	0.1	0.0	16.7
30 > u ≥ 10	0.5	0.3	0.0	0.0	0.1	0.9
10 > u	1.8	0.5	0.1	0.0	0.0	2.4
Total	59.1	8.2	1.1	0.1	0.1	68.6

TABLE 3.21 ITALY: VOLTAGE DIPS RELATED TO 150 KV - 132 KV NETWORK MONITORING SYSTEM (AVERAGE NUMBER OF VOLTAGE DIPS PER POINT, PER YEAR, ACCORDING TO THE UNIPEDE CLASSIFICATION)

Residual voltage u	Duration t (ms)					
(%)	20 < t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 60,000	Total
90 > u ≥ 85	25.5	6.9	0.9	0.4	0.1	33.8
85 > u ≥ 70	24.4	6.3	0.6	0.2	0.0	31.5
70 > u ≥ 30	12.6	4.7	0.3	0.2	0.0	17.8
30 > u ≥ 10	1.1	0.9	0.1	0.1	0.1	2.3
10 > u	1.9	0.6	0.1	0.0	0.1	2.7
Total	59.1	19.4	2.0	0.9	0.3	88.1

TABLE 3.22 ITALY: VOLTAGE DIPS RELATED TO MV BUS-BARS IN HV/MV SUBSTATIONS (AVERAGE NUMBER OF VOLTAGE DIPS PER POINT, PER YEAR, ACCORDING TO DURATION/RESIDUAL VOLTAGE CLASSES COMPLIANT WITH prEN 50160:2008)

Residual voltage u	Duration t (ms)					
(%)	20 < t ≤ 200	200 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 5,000	5,000 < t ≤ 60,000	Total
90 > u ≥ 80	37.7	5.5	1.1	0.9	0.1	45.3
80 > u ≥ 70	19.9	4.1	0.5	0.2	0.0	24.7
70 > u ≥ 40	38.8	6.6	0.6	0.2	0.1	46.3
40 > u ≥ 5	12.5	2.6	0.3	0.1	0.0	15.5
5 > u	0.3	0.0	0.0	0.0	0.0	0.3
Total	109.2	18.8	2.5	1.4	0.2	132.1

the Netherlands

TABLE 3.23 THE NETHERLANDS: EXAMPLES OF RESULTS FROM VOLTAGE DIP MEASUREMENTS IN THE NETHERLANDS

<table>
<tr><th>Residual voltage u</th><th colspan="4">Duration t (s)</th></tr>
<tr><td>(%)</td><td>0.01 – 0.02</td><td>0.02 – 0.1</td><td>0.1 – 0.5</td><td>0.5 – 2.5</td></tr>
<tr><td>90 > u ≥ 80</td><td rowspan="2">0; 0; 0; 0</td><td rowspan="2">2.5; 11; 43; 14</td><td rowspan="2">0.8; 3; 14; 7</td><td>0.1; 1; 1; 1</td></tr>
<tr><td>80 > u ≥ 70</td><td rowspan="2">0.2; 1; 3; 3</td></tr>
<tr><td>70 > u ≥ 50</td><td rowspan="2">0; 0; 0; 0</td><td rowspan="2">1.3; 9; 23; 7</td><td rowspan="2">0.2; 2; 3; 2</td></tr>
<tr><td>50 > u ≥ 40</td><td rowspan="2">0.2; 3; 3; 1</td></tr>
<tr><td>40 > u ≥ 1</td><td>0; 0; 0; 0</td><td>0.5; 4; 9; 5</td><td>0.9; 9; 15; 4</td></tr>
</table>

The numbers represent, from the left hand side:
(1) average number of dips at one location,
(2) the highest number of dips at one specific location,
(3) total number of dips at all locations and
(4) number of locations where this type has been monitored.

Norway, data collected during the period from 1993 to 2003[30]

TABLE 3.24 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN LV NETWORKS WITH REFERENCE TO MEASURING SITES

Residual voltage u	Duration t (ms)					
(%)	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000
90> u ≥ 85	17	14	4	3	0	0
85> u ≥ 70	9	2	2	0	0	0
70> u ≥ 40	10	3	0	0	0	0
40> u ≥ 1	6	1	0	0	0	0
1 > u	3	4	1	0	0	0

TABLE 3.25 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN MV NETWORKS WITH REFERENCE TO MEASURING SITES

Residual voltage u	Duration t (ms)					
(%)	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000
90> u ≥ 85	13	9	3	1	0	0
85> u ≥ 70	5	2	1	0	0	0
70> u ≥ 40	7	2	0	0	0	0
40> u ≥ 1	4	0	0	0	0	0
1 > u	1	2	1	0	0	4

30 In the period from 1993 to 2003, network companies reported on a voluntary basis actual voltage quality data to SINTEF Energy Research (Norwegian national research institute), who structured the data and published statistics, last one in 2003, as part of a national R&D project. This voluntary campaign included both continuous monitoring and random measurements, including even trouble shooting (customer complaints). In December 2003, the VQ database at SINTEF Energy Research contained measurement results from a total of 671 measuring points (NOTE: not all continuous monitored during the period). 39 out of 482 LV measurement sites are due to voltage quality complaints. Results are published with the permission of EBL Kompetanse AS.

TABLE 3.26 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN HV NETWORKS WITH REFERENCE TO MEASURING SITES

Residual voltage u	Duration t (ms)					
(%)	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000
90> u ≥ 85	9	6	2	0	0	0
85> u ≥ 70	3	1	1	0	0	0
70> u ≥ 40	4	0	0	0	0	0
40> u ≥ 1	1	0	0	0	0	0
1 > u	1	1	0	0	0	1

TABLE 3.27 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN EHV NETWORKS WITH REFERENCE TO MEASURING SITES

Residual voltage u	Duration t (ms)					
(%)	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000
90> u ≥ 85	3	2	1	0	0	0
85> u ≥ 70	1	1	0	0	0	0
70> u ≥ 40	1	0	0	0	0	0
40> u ≥ 1	0	0	0	0	0	0
1 > u	0	0	0	0	0	1

Portugal
Portugal has reported voltage dips based on the following:

- The definition of dip is in accordance with the EN 50160;
- In the transmission network, the information is related to the delivery points that were monitored during the entire year: 5 points in 2006 and 5 points in 2007;
- In the last years, there is no dip information available for a complete period of 1 year in the distribution network.

TABLE 3.28 PORTUGAL: NUMBER OF VOLTAGE DIPS IN TRANSMISSION DELIVERY POINTS AT 60 KV - 2006

Residual voltage u	Duration t (s)					
(%)	[0,01; 0,1]	[0,1; 0,25]	[0,25; 0,5]	[0,5; 1]	[1; 3]	[3; 20]
[10,20]	105 (1.6)	40 (0.6)	17 (0.3)	6 (0.1)	7 (0.1)	0 (0)
[20,30]	32 (0.5)	27 (0.4)	7 (0.1)	5 (0.1)	4 (0.1)	0 (0)
[30,40]	10 (0.2)	11 (0.17)	5 (0.1)	2 (0)	2 (0)	1 (0)
[40,50]	7 (0.1)	6 (0.1)	4 (0.1)	0 (0)	2 (0)	0 (0)
[50,60]	3 (0)	7 (0.1)	2 (0)	1 (0)	1 (0)	0 (0)
[60,70]	4 (0.1)	0 (0)	2 (0)	0 (0)	2 (0)	0 (0)
[70,80]	6 (0.1)	0 (0)	4 (0.1)	1 (0)	0 (0)	1 (0)
[80,90]	2 (0)	2 (0)	2 (0)	2 (0)	0 (0)	1 (0)
[90,99]	0 (0)	0 (0)	3 (0)	4 (0.1)	1 (0)	0 (0)

In brackets is the average number of dips per measuring unit

TABLE 3.29	PORTUGAL: NUMBER OF VOLTAGE DIPS IN TRANSMISSION DELIVERY POINTS AT 60 KV - 2007)					
Residual voltage u	**Duration t (s)**					
(%)	[0,01; 0,1]	[0,1; 0,25]	[0,25; 0,5]	[0,5; 1]	[1; 3]	[3; 20]
[10,20]	122 (1.9)	31 (0.5)	14 (0.2)	4 (0.1)	3 (0)	0 (0)
[20,30]	23 (0.4)	18 (0.3)	7 (0.1)	1 (0)	1 (0)	0 (0)
[30,40]	30 (0.5)	12 (0.2)	2 (0)	1 (0)	1 (0)	0 (0)
[40,50]	23 (0.5)	2 (0)	1 (0)	0 (0)	0 (0)	0 (0)
[50,60]	15 (0.2)	1 (0)	3 (0)	1 (0)	0 (0)	0 (0)
[60,70]	22 (0.3)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
[70,80]	14 (0.2)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
[80,90]	3 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
[90,99]	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

In brackets is the average number of dips per measuring unit

3.7.3 Publication of voltage quality data

Voltage quality data collected through the monitoring systems presented in the previous paragraphs are made available in different ways. Table 3.30 summarises the media that are currently in use in various countries.

TABLE 3.30 PUBLICATION OF VOLTAGE QUALITY DATA

	Belgium (HV)	**Czech Republic**	**France**	**Greece**	**Italy (MV)**	**Italy (HV and EHV)**	**the Netherlands**	**Norway**	**Portugal**
Web free (aggregated results)					X				
Web through password (aggregated results)						X			
DSOs, TSOs and customers that own measuring units (detailed results)					X	X			
Annual report of the Regulatory Authority			X				X		X
On request of users, regulatory authority and in case of litigation	X	X						X (current scheme)	
Sensitive customers every year (voltage dips)			X (1)						
Plan to publish a report after a full year of measurements				X					

(1) Only for the customers having subscribed to a tariff option.

In France for EHV and HV customers, results related to voltage dips are put in an annual report, including information on interruptions as well, provided by the TSO to each customer. Furthermore for MV and LV customers with non-adequate voltage quality levels, an internal report, made available in the regulator (CRE) annual report as well, is published.

In Italy, data relevant to monitoring on MV networks are available and published on a Web system called QUEEN. The access to QUEEN (http://QUEEN.ricercadisistema.it) is available to two different categories of users:

- The owners of the monitoring devices have access to the detailed measurement results (time of occurrence and characteristics of any single disturbance) and to statistics of disturbances recorded by their monitoring devices over selected intervals of time. The access is made through a password that allows the non-disclosure of proprietary information.
- The public may access the QUEEN and request the processing and reporting of the data collected by the monitoring system aggregating the results in groups of monitoring devices.

Detailed results available to the monitoring device owners are organised in tables that report the list of the characteristics of the given VQ parameter as a function of time (in case of parameters continuously recorded as voltage variations, harmonics, flicker, etc.) or as sequence of events (in case of dips, interruptions, rapid voltage changes etc.). For parameters continuously recorded, the user can obtain graphs representing them as a function of time. In case of events, the user can download original waveshapes recorded by the monitoring device in an interval of time triggered by the event occurrence.

Aggregated results may be obtained by the public over groups of monitoring devices chosen on a spatial criterion (the Italian regions or the entire country) and groups of monitoring devices chosen on the basis of electrical characteristics (nominal/declared voltage level, insulated neutral or compensated neutral networks, rated power of the HV/MV transformer, etc.). The results are organised in tables that report the statistics of the VQ parameters over time intervals.

Both in cases of detailed and aggregated results, the VQ parameters exceeding the limits indicated by EN 50160 are indicated by coloured flags.

Data relevant to monitoring on EHV and HV networks is available and published on a Web system called MONIQUE. The access to MONIQUE (http://procedure.terna.it/monique) is possible only with a password for both detailed and aggregated results (produced in the same way as those of the monitoring system in MV networks). Aggregated results are available per spatial criterion (the Italian regions or the entire country), per relevant zone of the transmission system and per voltage level.

In Norway, upon enquiries from customers (or possible future customers) grid companies shall provide information about the continuity of supply and the voltage quality in their own grid. The information shall be provided within 1 month. The following is the minimum the companies shall be able to provide:

- Nominal value for the supply voltage in connection points and voltage quality limits;
- Results of fault analyses carried out pursuant to the regulations relating to the system responsibility;
- Results of continuous monitoring of voltage quality;
- Estimated historical and expected number of short interruptions in the connection point, based on historical data collected;
- Estimated historical and expected number and duration of long interruptions in the connection point, based on historical data collected;

- Estimated number of historical and expected voltage swells and voltage dips in the companies' own supply areas, based on historical data recorded through continuously monitoring;
- Calculated minimum and maximum short-circuit power for connection points above 1 kV. Significant changes in the short circuit power shall be notified to affected customers;
- Special conditions in the grid that may have an effect on the quality of supply, in order to prepare grid customers for conditions that might arise. Examples of these include: particular risk of phase interruptions in coil earthed networks or transients over-voltages, use of automatic reconnection, etc.

In Portugal, the operator has to send the regulator, ERSE, information about voltage quality 45 days after the end of each quarter. The operator sends ERSE a sample of the registered information in each monitoring point, normally the values of a representative week and the values of the weeks in which some limits were not fulfilled. It has not established a methodology to select the representative weeks.

3.8 Planned Voltage Quality Monitoring Systems

Some countries are planning new schemes or extensions of current schemes on voltage quality monitoring.

The Austrian regulator plans to permanently monitor the voltage quality according to EN 50160:

- Measuring VQ at MV-level will be done area-wide by technical/scientific or mathematical models.
- Measuring VQ at LV-level will be carried out punctually.

Based on the Electricity-Statistics Regulation from 2007, the data collection period runs from 1st January 00:00 until 31st December 24:00. The data has to be announced for the first time for the calendar year 2008; a complete announcement has to be done for 2010.

In Belgium, ELIA plans to install 50 to 100 additional VQ monitoring devices in the coming years at voltages between 30 kV and 380 kV.

Mentioned below are the start dates from which there was (or will be) continuous monitoring of voltage quality in the Czech Republic for different kinds of points. Planned voltage quality monitoring system can be found as well.

- Transfer points TS/DS — continuously monitored (since 1/1/2006)
- Delivery points 110 kV — continuously monitored (since 1/1/2007)[31]
- Substations output voltage 110 kV/MV — continuously monitored (from 1/1/2010)[32]
- Delivery points MV — selection[33]
- Substations output voltage MV/LV — selection[33]
- Delivery points LV — selection[33]

31 As for delivery points 110 kV these parameters are monitored and archived from 1 January 2007 if recognised values of some of guaranteed parameters exceed 50% oflimit values for the given delivery point during the preliminary weekly monitoring (repeated every 2 years). The permanent installation can be avoided if the distribution system operator is able to document levels of these characteristics by way of measured values of neighboring delivery points or transfer points of transmission/distribution system.

32 Substations output voltages have been monitored and archived since 1-1-2008 if recognised values of some of guaranteed parameters exceed 50% of limit values for the given point during the preliminary weekly monitoring (repeated every 2 years).

33 Delivery points MV are monitored in case of litigation, claims for connection of users with sensitive technologies or according to the experiences of the DSO.

In France, for EHV and HV monitoring system, this issue is being studied at the moment and the evolution of the deployment will probably soon be reconsidered. 50% of MV customers should be equipped with monitoring devices by 2010.

In the Netherlands, all new connection points in the EHV network will be monitored. Furthermore, at specific locations where voltage quality problems have arisen, or are expected to arise, the voltage quality will be monitored.

Additional information A 3.5 - Innovative Monitoring Through Smart Meters

In France, with the development of Automated Meter Management (AMM) systems, it will be possible to measure interruptions and the voltage quality; date and duration of long and short interruptions, and the date and duration of supply voltage variations that are outside predefined thresholds. The AMM will measure supply voltage variations on an average interval of time adjustable (at first, the time will be 10 minutes). In case of excursion of the voltage out of an average range defined by 2 thresholds parameters (at first, the thresholds will be +10% and -10% in accordance with the decree of 24th December 2007), the meter will record the value of this voltage and the dates of the event's beginning and end item averaged. This will all be measured at each LV customer premises. With the experimental AMM project, 300,000 smart meters will be installed by the end of 2010. The voltage level will be then measured at the LV customers concerned.

In Italy, starting from 2009, all smart meters for LV customers must be able to record and collect measurements relevant to slow voltage variations according to EN 50160. It has still to be put under consultation how the monitoring campaign shall be done (for instance: samples of smart meters selected per different criteria: at the end of long LV lines, aerial/cable LV lines, etc.). Furthermore, a "one off" incentive has been introduced for DSOs that will use smart meters and AMM systems, as from 2010, in order to record the number and the list of LV customers involved in each long unplanned interruption.

In the Netherlands, the Netbeheer Nederland has, in close cooperation with the TSO and DSOs and KEMA[34], defined several requirements for smart meters that are related to power quality. These requirements are not mandatory by law, but are used in the tenders for smart meters. In the Netherlands, it will be possible to perform voltage quality measurements with all new smart meters. However, the TSO or every DSO can decide whether to monitor the voltage quality or not.

In Norway, it has been decided that smart meters shall be installed for all end-users by around 2013. During 2008, the regulator (NVE) sent a new regulation to a public hearing. NVE is currently in the process of considering requirements for such smart meters; hence it is yet not decided whether to require quality of supply monitoring.

In Spain, only certain recommendations about the capabilities of new smart meters to collect quality parameters have been considered in actual regulation (Royal Decree 1110/2007). Some distribution firms have declared their intentions to follow this recommendation and are going to introduce equipment that is not only able to record and collect measurements but that also has features to register the duration for which the voltage is beyond the thresholds and continuity.

3.9 Main Findings on Voltage Quality

Voltage quality is the most technical and complex part of the quality of electricity supply. Voltage quality can be affected by all the parties connected to the power system and can be divided into several different voltage disturbances. Voltage disturbances can be grouped into voltage events and continuous phenomena for which the latter can be most easily regulated in European norms or national regulations by minimum requirements. A good knowledge of the real situation is a preliminary step towards any kind of regulatory intervention; hence monitoring schemes are of vital importance.

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34 Consulting company - www.kema.com

In Europe, the most important norm regarding characteristics of the voltage is the CENELEC norm EN 50160. In several countries, requirements have been introduced other than the ones stated in this norm which is due to dissatisfaction with the current edition of the EN 50160. Following a wide consultation process by ERGEG between 21st December 2006 and 22nd February 2007, the Conclusions Paper "Towards Voltage Quality Regulation in Europe" was published on 18th July 2007. The ERGEG paper contains the European regulators' position on several aspects of EN 50160 needing improvements and identifies gradual steps that can be taken in order to achieve such improvements. In parallel, since the year 2006 the CEER has participated actively in the work of the CENELEC's specific working group TC 8X WG1 in order to revise the EN 50160 in a consensual way, according to CENELEC procedure, where several experts are deeply involved.

However, the European regulators note that the consumers' views have not been adequately represented in the consultation process and in the CENELEC work (through active participation). This can ultimately lead to underestimation of the benefits of revising voltage quality norms or over-evaluating costs that might be incurred by new norms. It is important to have a sound balance between all the relevant stakeholders in the "world of standardisation".

Customers requiring verification of actual voltage quality levels on their own connection point are generally entitled to have their request satisfied. The regulator can either put an obligation on distribution companies or regulate the customer's right to measure voltage quality with its own voltage quality recorder; in the latter case, in order to assure that measurements are valid for the distribution company, the voltage quality recorder must comply with requirements from the regulator, national or international norms or technical criteria set by the operator.

In some countries, customers and distribution companies have the opportunity to agree upon a special contract with contractual quality levels and extra-revenue for the distribution companies; only in a few countries do regulators have the scope to intervene in this market mechanism. Where the regulator intervenes in power quality contracts, his role can be either ex-ante, determining the general form of the contracts, or ex-post, monitoring the diffusion and actual application of power quality contracts.

Surveys carried out in 3 different countries show significant large costs for affected end-users due to poor voltage quality. Surveys have been carried out in Norway, Sweden and Italy. More details can be found in section 3.6.

The monitoring schemes for voltage quality developed in different countries show no harmonisation among countries. The lack of harmonisation concerns devices, voltage levels and voltage disturbances to be monitored, number and localisation of instruments, classification of dips and swells and reporting and publication of results. In particular concerning dips, the majority of countries report in their classification table the average number of dips per measurement point in a given time period. Other countries report the summation of the number of dips registered in each measurement point in a given time period.

The lack of harmonisation includes also regulatory recommendations about the use of voltage quality monitoring devices and current/voltage transducers for both monitoring campaigns and contractual purposes.

Finally, smart meters, because of their scarce deployment and lack of regulatory requirements, seem to not yet constitute a suitable tool for monitoring voltage quality, even for a few parameters.

3.10 Conclusions and Recommendations on Voltage Quality

Despite the work done by CEER over the years and the deployment of significant monitoring systems, voltage quality still remains a new issue for many regulators. A few regulators have still not introduced in their regulation the idea of individual verification for customers. 11 countries reported to have monitoring systems running or planned; only in 5 of those cases have the monitoring initiatives been promoted by the regulators. Therefore, the following aspects should be carefully taken into consideration:

- Countries should consider monitoring voltage quality continuously and publish results regularly. It is further recommended that CEER member countries disseminate experience among themselves and that an effort is made in order to consolidate the European view on voltage quality monitoring.
- The obligation for system operators to provide individual verification of voltage quality to customers upon their request should be adopted by all countries, even in the absence of a former complaint by the requesting customer and in the absence of power quality contracts as well.

CEER recommends that in the near future a workshop on voltage quality monitoring should be organised between relevant stakeholders. The workshop could be an excellent opportunity for disseminating experiences and views on voltage quality monitoring between regulators and other stakeholders. The aim of the workshop could be to reach recommendations regarding how to perform (harmonised) continuous monitoring of voltage quality in different European countries.

Harmonisation between countries should include the accuracy of the whole measurement chain (monitoring devices and current/voltage transducers) for both statistical and contractual purposes.

It is recommended that there is a continuation of the cooperation between CEER and CENELEC in order to further revise the technical norm EN 50160. This process should include representatives from all relevant stakeholders, including customers, manufacturers of end-use equipment, system operators and the manufacturers and suppliers of measurement equipment

Due to the limited use of market mechanisms aimed at improving quality, further research and information are welcome on power quality contracts which can result in an efficient outcome to satisfy special quality needs without increasing general tariffs.

The CEER also recommends investigating whether it is feasible to use smart meters for measuring voltage quality parameters in an efficient way in the future.

4 COMMERCIAL QUALITY

4.1 What Commercial Quality is and why it is important to regulate it

Commercial quality relates to the nature and quality of customer services provided to electricity consumers. In a liberalised electricity market, the customer concludes either a single contract with the supplier or separate contracts with the supplier and the DSO, according to national regulations. In both cases, however, commercial quality is an important issue.

Commercial quality is directly associated with transactions between electricity companies (either DSOs or suppliers, or both) and customers, and covers not only the supply and sale of electricity, but also various forms of contacts established between electricity companies and customers. There are several services that can be requested by customers, such as new connections, starting and terminating supply, meter verification, and so on, and each of them is a transaction that involves some commercial quality aspects. The most frequent commercial quality aspect is timeliness of services requested by customers.

There are lots of question marks and debates on the necessity of regulating commercial quality. The most frequently asked question is whether it is really necessary to regulate the licensee's performance, by setting up incentives and creating regulations and requirements, in a competitive market where competition itself is supposed to force companies to perform above a certain minimum level. It is commonly known that regulation may contribute to competition in terms of some network activities (e.g. metering) although this is not a practice applied in all CEER member countries. While competition is well developed in supply, where new market entrants variegate the overall picture, in many cases competition does not apply equally to all customer groups (e.g. to residential customers). Moreover, it is important to have quality regulation in place for the incumbent electricity companies which have exclusive rights to some activities (traditional monopolies).

Another debated aspect is incentive regulation for network charges. This price-regulation method (price/revenue cap, price formula, pricing period) provides network companies with strong incentives to reduce their overall costs - this includes also operational expenditure and capital expenditure - (in order to increase efficiency). A reduction of operational expenditure may result in a decline of actual quality levels of network services or at the very least in no improvement in line with customers' expectations. This may easily be the result in countries where the principle of incentive-based regulation in network price regulation is either just being developed or could be adopted in the near future, while no service quality standard exists or is supposed to be issued only at a later stage.

There is also a question as to whether it is appropriate to maintain minimum standards with regard to supply when competition is fully developed, such that companies compete in providing standards which exceed these minimums. The fact is that some commercial quality aspects (e.g. times for connections) relate to distribution networks and therefore, given their monopolistic nature, they should still be regulated.

Commercial transactions between an electricity company and a customer are traditionally classified as follows:

- **Pre-contract transactions,** such as information on connection to the network and prices associated with the supply of electricity. These actions occur before the supply contract comes into force and incorporate actions both by the DSO and the supplier. Generally, customer rights with regard to such actions are set out in codes (such as Connection Agreements and the General Conditions of Supply Contracts) and are approved by the regulatory authority or other governmental authorities.
- **Transactions during the contract period,** such as billing, payment arrangements and responses to customer queries, complaints and claims. These transactions occur regularly, like billing and meter readings, or occasionally, e.g. when the customer contacts the company with a query or a complaint. The quality of service during these transactions can be measured for example by the time the electricity company needs in order to provide a proper reply. These transactions could relate to both the DSO and the supplier and could be regulated for quality according to the regulatory framework of the particular country.

Important factors in analysing how a company interacts with and responds to the needs of customers include the presence or absence of a complaint handling procedure, how the complaint is handled and, in case it is settled satisfactorily, what corrective action is to be taken by the company.

One of the most effective ways to ensure that regulation will result in a well-functioning customer service is the existence of commercial quality rules and standards. This has been more or less achieved in all countries through the use of regulations or codes, performance standards, the publication of information on commercial quality of the companies, as well as through strategies to encourage customer participation. The involvement of customers and their representatives can make an important contribution to quality regulation; further, customer surveys can reveal both customer expectations and satisfaction with the current level of service.

4.2 Main Aspects of Commercial Quality

Commercial quality involves so many aspects that it is hard find out how many commercial quality indices exist. Further, attention must be placed on many details in defining each commercial quality indicator. Hence, one has to be careful when comparing the commercial quality indices of different countries, because of the differing interpretations of the same indicator definitions by the responding regulators.

The difficulties in defining, homogenously, commercial quality indicators were already underlined in the 3rd Benchmarking Report. 25 commercial quality indices were included in the questionnaire back in 2005. During the data collection phase for the 4th Benchmarking Report, 24 new indicators (applied specifically in a single country) were added by the regulatory authorities who had indicated the original 25 indicators. The resulting picture was very diverse and the outcome of the answers to the questionnaires was difficult to assess.

The uncertainty mentioned above was further increased by a new interpretation problem: which sort of operator the commercial quality relates to. Former (regulated) traditional supply companies have been replaced by traders acting under competitive conditions (theoretically, in an efficient retail market). Meanwhile, the DSO still performs a monopoly activity which is regulated in detail; in most countries, the distribution activity is supposed to be separated from the supply activity. At the same time, DSOs may perform other activities (like grid maintenance, repairs, restoration of supply, etc.) that involve commercial aspects to a high degree. The term “commercial quality” cannot strictly be linked to the term “trade”, and thus other activities must also be included in the commercial quality assessment.

4.2.1 How to regulate commercial quality

There are mainly two types of quality standards for commercial quality:

- Guaranteed Standards (GSs) refer to service quality levels which are set by the regulator and which must be met in each individual case. If the company fails to provide the level of service required by a GS, it must compensate the customer affected, subject to certain exemptions.
- Overall Standards (OSs) refer to a given set of cases (for instance, all customer requests in a given region for a given transaction) and must be met with respect to the whole population in that set. OSs in commercial quality are mainly expressed through a percentile; e.g., at least 90% of cases for connecting a new customer, when the connection calls for complex works, must be carried out in less than 30 days. This kind of OS establishes the minimum percentage of transactions (90%) that must be carried out within a certain time limit.

There is not a single rule for choosing how to regulate commercial quality aspects; it is up to the regulator to choose between GSs and OSs. GSs give an effective protection to customers, as customers are entitled to be compensated if the GSs are not met (subject to certain exemptions). On the other hand, OSs are preferred with respect to aspects of service for which the regulator does not consider it appropriate to impose individual guarantees, but for which customers in general should expect companies to deliver pre-determined, minimum levels of service quality. In contrast to the case of a GS, no compensation is paid to customers for breach of an OS, but the regulator can take measures against a company that systematically fails to apply OSs.

In addition to GSs and OSs, regulators can set requirements in regulation in order to achieve a certain quality level. These quality levels can be set according to what the regulator deems appropriate, e.g. a minimum level which must be met for all customers at all times. If the requirements set by the regulators are not met; in most cases the regulator can issue sanctions, e.g. financial penalties. Such kinds of requirements are referred to as “Other Available Requirements” (OARs).

In order to identify the most frequently used indicators for each group, during the preparation of the questionnaire used for this Report the indicators considered in the 3rd Benchmarking Report were reviewed, looking at the number of countries that gave actual values for commercial quality standards in 2005.

Table 4.1 shows the number of commercial quality standards for each country, separated by GSs, OSs and OARs. The table shows clearly that regulators make more use of GSs than of OSs. However, in many countries requirements applicable to each single transaction are applied as well, albeit without compensation to the customer when this kind of requirement is not respected. From the customer protection point of view; the most efficient tools are GSs, or minimum requirements set by the regulator where sanctions can be issued. The experience of CEER member countries with advanced commercial quality regulation shows that OSs have been decreasing or disappearing while more and more GSs have come into force over time; this process is likely to continue in other countries in the near future.

TABLE 4.1 NUMBER OF COMMERCIAL QUALITY STANDARDS FOR EACH COUNTRY (REQUIREMENTS FOR MARKET OPENING ARE NOT INCLUDED IN THE CALCULATION)

Country	Guaranteed standards (GSs)	Overall standards (OSs)	Other available requirements (OARs)	Total
Austria		10	1	11
Belgium-Flemish			8	8
Belgium-Walloon		6		6
Cyprus	10		3	13
Czech Republic	11			11
Estonia		4	3	7
Germany			1	1
Hungary	16	4		20
Italy	8	4	4	16
Latvia		1	15	16
Lithuania			12	12
Luxembourg			9	9
Norway			12	12
Poland			8	8
Portugal	7	4	1	12
Romania		12		12
Slovenia	6	2	9	17
Spain	9	2		11
Sweden			4	4
United Kingdom	6		1	7
Total	73	49	91	213

4.2.2 Main groups of commercial quality aspects

In order to simplify the approach to the complex issue of commercial quality, indicators relating to commercial quality have been grouped into four main groups (Table 4.2), divided as shown in Table 4.3.

TABLE 4.2 GROUPING OF COMMERCIAL QUALITY ASPECTS

I. Connection
II. Customer care
III. Technical service
IV. Metering and billing

TABLE 4.3 NUMBER OF COUNTRIES WHERE COMMERCIAL QUALITY STANDARDS (GS, OS OR OAR) ARE IN FORCE, PER GROUP AND PER COMPANY TYPE

Group	Standard	DSO	SP	USP	Total
I. Connection	Cost estimation for connection	12			12
	Time between signing contract and the start of supply	10			10
	Time for response to customer claims for network connection	13			13
	Time for connecting new LV customers	11			11
II. Customer care	Punctuality of appointments with customers	7			7
	Response time to customer complaints in writing	12	6	8	26
	Response time to customer queries in writing	10			10
	Response time, queries on costs and payments	10			10
III. Technical service	Time for answering a voltage complaint	12			12
	Time until restoration following failure of DSO fuse	11			11
	Time for giving information on a planned interruption	13			13
IV. Metering and billing	Time for meter inspection in case of meter failure	7			7
	Time from notice-to-pay until disconnection	15	8	8	31
	Time for restoration of power supply following disconnection due to non-payment	14	7	8	29
	Yearly number of meter readings by the designated company	11			11

The results of the benchmarking are described in section 4.3 using the four groups as a reading guide.

4.2.3 Monitoring actual levels of commercial quality

There are two ways to monitor the actual level of commercial quality:

- Monitoring the average value of the indicator, for instance average time for connection;
- Monitoring the percentage of cases in which the maximum time allowed is respected, i.e. the actual performance time is below (or above) the standard.

It is important to note that the first type of measurement of actual levels does not depend upon standards and is therefore comparable between countries (assuming that requests of the same type are considered); while the second measurement, also called compliance percentage, is not meaningful without knowing the standard which is referred to.

Unfortunately, monitoring the actual levels of commercial quality is not very widespread; only a few countries regularly monitor the average times or the percentage in respect of the maximum allowed times for commercial quality transactions. In the questionnaire for this Report, data on the actual levels for 2007 were requested. In the end, some countries could not provide data for 2007 but were able to provide data for 2006. The actual values submitted from various countries are presented in Annex 3.

4.2.4 Data availability for benchmarking

In preparing this 4th Benchmarking Report, a questionnaire was distributed among national regulatory authorities. Compared with the questionnaire used for the commercial quality chapter of the 3rd Benchmarking Report, significant changes have since taken place in the electricity industry (liberalisation, unbundling). Hence, it was decided to revise the structure of the questions, separating questionnaires related to commercial quality for DSOs, and for suppliers. For suppliers, a distinction is made between "ordinary" suppliers (SP) which operate in the free market and universal suppliers (USP), which in some countries exist in order to supply domestic and small customers who do not choose a SP in the free market or who rely on their supplier of last resort (in cases when the SP fails to supply electricity for a variety of reasons).

21 regulators provided detailed or partial answers to the questionnaires. Responses are included in Table 4.4 below.

TABLE 4.4 DATA AVAILABILITY FOR COMMERCIAL QUALITY IN THE 4TH BENCHMARKING REPORT. (BELGIUM GAVE 2 RESPONSES FROM DIFFERENT REGIONS)

	DSO				SP				USP			
	Standards	Actual values	Compensation	Market opening	Standards	Actual values	Compensation	Market opening	Standards	Actual values	Compensation	Market opening
Respondents with available standards/ requirements	19	7	7	16	10	1	3	13	10	3	5	10
Not available	2	6	5	0	4	3	2	1	3	4	2	2
No answers	1	9	10	6	8	18	17	8	9	15	15	10
Total number of respondents	22	22	22	22	22	22	22	22	22	22	22	22

As shown in Table 4.5, the majority of regulatory authorities apply standards for DSOs, although actual values and compensation were missing in some cases. In the category of SPs and USPs, a lower response was observed, especially for standards for SPs. This is a clear indication of a regulatory policy of setting only a few standards for supply, as this is a free market activity. It can also be an indication that in these cases regulation concerning SP/USP have not yet been developed, as full market opening is quite recent. In most cases, answers for SP and USP questions were very similar.

Based on this data, the role of the regulatory authorities seems to cover mainly the activity of the DSO operating in a monopoly, whereas there is about half as much regulation concerning market players like SPs and USPs. The number and the distribution of the standards for the latter two types of suppliers do not differ significantly; however SPs are less regulated than USPs. In the rest of this section, the statements regarding SPs and USPs are introduced jointly.

It should be noted that, without a detailed analysis of the definitions of the individual commercial quality indicators, one must be very cautious when comparing data. The general experience of quality regulation can be used for an analysis of existing trends and expectations.

As far as compensation due in case of mismatching GSs is concerned, a great variety of applications was evident from the replies received. Most typically, standards can be classified by the type of payment, e.g. automatic or upon request or voluntary or bilateral agreements when compensations are not set by regulators but companies are recommended to set some compensation, like in Austria, as shown in Table 4.5.

TABLE 4.5 COMPENSATIONS DUE IF COMMERCIAL QUALITY GUARANTEED STANDARDS ARE NOT FULFILLED

Country	Automatic	Upon customer's request	Voluntary or bilateral agreements
Austria			X
Cyprus		X	
Czech Republic		X	
Hungary	X	X	
Italy	X		
Portugal	X		
Slovenia		X (proposal)	
Spain	X		
United Kingdom		X	

Automatic compensation, or other available regulatory requirements where sanctions can be issued, are generally prefered in order to guarantee an effective customer protection. In Annex 3, a lot of information is available on the amounts of compensation; this can vary, according to each CEER member country - by the consumer sector (residential or not), or by the voltage level (LV, MV etc.) or depending upon the delay in executing the transaction according to the standard.

4.3 Main Results of Benchmarking Commercial Quality Standards

4.3.1 Group I: Connection

As mentioned earlier, this Group concerns commercial quality standards that are applicable to DSOs and are applied by a large proportion of respondent regulators. The reason is two-fold: on one hand, both speedy clarification of the network access conditions and timeliness of concrete connections are of high priority for customers; on the other hand, connection is mainly related to distribution and is therefore strictly related to monopoly regulation (although in a few countries this activity can be performed by independent operators).

There are four main commercial quality indicators used for setting standards related to connections (the corresponding detailed table in Annex 3 is indicated in brackets):

- Time for response to customer claims for network connection (Table CQ 1.1);
- Time for cost estimation for simple works (Table CQ 1.2);
- Time for connecting new LV customers to the network (Table CQ 1.3);
- Time between signing contract and the start of supply (Table CQ 1.4).

As can be easily seen, the above listed four quality indicators represent the whole process for connection; first there is the request for connection, to which there are two possible responses (feasibility response and estimation of costs); then, when the estimated cost is accepted by the customer, there is the work for realising the connection; last, there is the activation of the supply (only in this last step can the supplier be involved).

TABLE 4.6 COMMERCIAL QUALITY STANDARDS FOR CONNECTION-RELATED ACTIVITIES

Quality indicator (Group I)	Countries (grouped by type of standard)	Standards[1] (median value and range)	Compensation[2] (median value, only GS)	Company involved
Time for response to customer claims for network connection	**GS:** CY, CZ, ES, HU, SI[3] **OS:** AT, BE(Walloon), EE, LV, RO **OAR:** LT, LU, NO	14 working days (range 8-30)	€ 30	DSO
Time for cost estimation for simple works	**GS:** CY, HU, ES, IT, SI[3], UK **OS:** AT, BE(Walloon), EE, PT **OAR:** BE(Flemish), NO	14 working days (range 5-90)	€ 30	DSO
Time for connecting new LV customers to the network	**GS:** CY, ES, IT, LT, SI[3] **OS:** AT, BE(Fle), PT **OAR:** BE(Wal), LU, NO	15 working days (range 6-30)	€ 30	DSO
Time between signing contract and the start of supply	**GS:** HU, ES, IT, SI[3] **OS:** AT, BE(Walloon), PT **OAR:** DE, LV, NO	6 working days (range 2-14)	€ 30	DSO, SP/USP

Legend: GS guaranteed standards; OS overall standards; OAR: other available requirements
Notes
(1) when differentiated, only standards for LV customers have been considered
(2) when differentiated, only compensation applicable to household customers has been considered
(3) regulatory proposal, currently under consultation

Table 4.6 shows a synthesis of the commercial quality standards for connection-related activities. It is important to remember several aspects in detail:

- Standards for connection-related activities often have a complex structure, depending upon the complexity of the work to be done; just as an example, Table 4.7 gives the diverse standards in Spain for the maximum time to connect LV and HV customers to the networks. A similar structure is adopted in other countries, more often dividing “simple works” from “complex works” (though the division is not the same in all countries).
- Compensation when guaranteed standards are not fulfilled can have a more complex structure as well; in many countries compensation depends upon voltage level, or the type of customer (household or business customer). In Italy, for instance, compensation is € 30 for domestic customers, € 60 for business LV customers and € 120 for business MV customers.

TABLE 4.7 SPANISH STANDARDS FOR MAXIMUM TIME FOR CONNECTION, DIFFERENTIATED ACCORDING TO VOLTAGE LEVEL AND TECHNICAL COMPLEXITY OF THE WORK

Task	Type of supply	Criteria	Obligation
Completion of the works needed for the new connections	Supply at low voltage	Whenever it is not necessary to carry out any expansion of the low network	5 working days
		Whenever solely the low voltage network needs to be expanded	30 working days
		Whenever several transformer centres need to be built	60 working days
	Supply at high voltage	Mains connection to a single customer with a nominal supply voltage equal to or less than 66 kV	80 working days
		Other high voltage supply	Deadlines determined in each case in line with the importance of the work to be done

4.3.2 Group II: Customer care

While in Group I (connection) the most important actors are the DSOs, for customer service activities (Group II) the most important actors are suppliers (SP/USP; see section 4.2.4). This explains why the number of standards is lower in Group II than in Group I, considering that supply is a free market (competitive) activity.

There are many issues related to customer service, according to the different ways customers can contact the supplier: in written form through letters (fax or e-mail), or through customer centres or, more frequently, through call centres.

The most developed area for standards relates to answering customer letters. Table 4.8 gives a synthesis of the commercial quality standards for this type of customer service activity. Standards related to DSOs and to SPs/USPs have been distinguished, in order to have more homogeneous benchmarking.

TABLE 4.8 COMMERCIAL QUALITY STANDARDS FOR CUSTOMER SERCICE ACTIVITIES

Quality indicator (Group II- Answering customer letters)	**Countries** (grouped by type of standard)	**Standards**(1) (median value and range)	**Compensation**(2) (median value, only GS)	**Company involved**
Response time to customer queries in written form	**GS:** CY, ES, HU **OS:** IT, PT, RO **OAR:** LT, LV, NO, SI	15 working days (range 5-30)	€ 20	DSO
Response time to customer complaints in written form	**GS:** CY, CZ, ES, HU, PT **OS:** IT **OAR:** BE(Flemish), NO, LT, LV, SI, UK	15 working days (range 5-30)	€ 20	DSO
	GS: CZ, HU **OS:** IT, RO **OAR:** LT, LV	15 working days (range 5-30)	€ 20	SP
	GS: CZ, HU, PT **OS:** EE, IT, RO **OAR:** LT, LV	15 working days (range 5-30)	€ 20	USP
Response time, queries on costs and payments	**GS:** CY, ES, HU, UK **OS:** AT, SI, RO **OAR:** NO, LT, LV	15 working days (range 2-30)	€ 20	DSO
	GS: HU	15 working days (only 1 country)	€ 20	SP/USP

Legend: GS guaranteed standards; OS overall standards; OAR: other available requirements
Notes
(1) when differentiated, only standards for LV customers have been considered
(2) when differentiated, only compensation applicable to household customers has been considered

As far as answering client letters is concerned (for details see Annex 3 ,Tables CQ 1.5, CQ 1.6, CQ 1.7 and CQ 1.8), standards used for responding to other customer queries, complaints and claims are relatively homogenous. For some countries, it must be noted that:

- The professional and prompt handling of complaints is of great importance since customers experiencing unsuccessful attempts for settlement may switch companies. However, maintaining regulation on complaint handling is advisable even in countries with full market opening. The prominent example of the United Kingdom is interesting because, in a country with a fully developed competitive market, SPs are obliged to have an effective remedy procedure, instead of having to comply with a specific time limit for answering complaints.
- In Norway, only client letters requesting historical and expected future data on voltage quality and continuity of supply are included in the regulations, with an exact limit of 1 month. If this limit is not respected, the regulator can issue a violation fine or issue compulsory fines until the letter is answered.
- It should be recognised that the responding-to-complaints standard might not be perfectly fulfilled (i.e. 100%), as in some cases it is impossible to provide a meaningful response in the given timeframe. In these situations, customers should be notified of the reasons for delay and the expected reply date.
- As regards the time for providing a response to questions in relation to costs and payments, it must be noted that rules are quite heterogeneous: in a few countries standards are imposed on DSOs, and in other countries upon SPs and USPs or only upon USPs. In any case, it is of great importance that customers receive an answer before notices-to-pay are sent or disconnections occur. The standards applied on SP/USP show a more homogenous picture than in the case of DSOs. Licensees have to respond to queries regarding costs and payments within 5 to 15 days. Presumably, customers make enquires because they would like to switch supplier.

A new area is becoming trickier for regulators; i.e. customer service through call centres. So far, only a few regulators have standards for this relatively new matter.

Both for DSOs and SPs/USPs, the two most important indicators for call centres are average holding time and service level index. It is not possible to attach a customer compensation for these indicators, but in a few cases (such as Hungary and the United Kingdom; and Italy since 2008) a significant penalty can be imposed by the regulator upon companies with the worst performing call centres. It is important to state that:

* Average holding time is not always recorded in the same manner: some regulators do not count the time for "navigation" within the "interactive voice responder" (IVR), whilst others do count this time in the average holding time; this explains why existing standards are not easily comparable.
* Service level index can be calculated in at least two ways: as the percentage of calls to which a response has been given in a given time (normally excluding the IVR navigation time) or as the percentage to which a response has been given at all.

The issue of monitoring the waiting time for customers who visit customer centres in person is put into practice only in a couple of countries (Hungary and Portugal), in both cases as OSs.

Lastly, a very important issue is that of appointments with customers. Some operations require the presence of the customers; regulators can impose standards (mainly on DSOs and mainly GSs) in order to assure punctuality in setting appointments and meeting with customers. Table 4.9 illustrates the situation: the maximum time band for punctuality varies between 2 and 4 hours in most countries; the levels of compensation payments range between € 18 and € 80 (higher compensation relates to the weakest standard). See Table CQ 1.9 in Annex 3 for more details.

TABLE 4.9 COMMERCIAL QUALITY STANDARDS FOR PUNCTUALITY OF APPOINTMENTS WITH CUSTOMERS

Quality indicator (Group II)	Countries (grouped by type of standard)	Standards[(1)] (median value and range)	Compensation[(2)] (median value and range)	Company involved
Punctuality of appointments with customers	**GS:** CY, CZ, HU, IT, PT, SI[(3)], UK	3 hours (range 2,5 - 4 hours)	€ 25 (range 18-80)	DSO

Legend: GS guaranteed standards; OS overall standards; OAR: other available requirements
Notes
(1) when differentiated, only standards referred to LV customers have been considered
(2) when differentiated, only compensation applicable to household customers has been considered
(3) regulatory proposal, currently under consultation

4.3.3 Group III: Technical service

This Group includes indicators related to technical service:

- Time for giving information on a planned interruption (Annex 3, Table CQ 1.10);
- Time until restoration following failure of DSO fuse (Annex 3, Table CQ 1.11);
- Time for answering voltage complaint (Annex 3, Table CQ 1.12).

Of course, all the listed indicators relate to distribution activities, therefore standards of Group III mainly refer to DSOs. Only Hungary has a standard on SP/USP in case a customer is erroneously disconnected by the DSO due to false instructions of SP/USP on customers without debts to be disconnected.

Regulation of the time for giving information on a planned interruption is the most prevalently used indicator out of the 25 indicators involved in this analysis. In every country, some deadline requirements are applied, but this deadline is not classified as a commercial quality standard in all countries (e.g. in Italy it is not a quality standard but a regulatory requirement). In a few countries (Hungary and Cyprus), the time for giving information on the planned interruption is very long (with 15 days and 20 working days, respectively).In most countries, a deadline between 1 and 2 days is applied. Sometimes, this deadline is differentiated according to the type of work requiring planned interruptions or per voltage level. The aim of notifying an interruption in advance is to give the end-user the possibility to implement proper measures in order to reduce the negative consequences of the interruption. The necessary time in advance will vary between different end-users and in particular between end-user groups, i.e. industrial versus residential. The negative consequences of an interruption will also vary between different groups of end-users.

Among other indicators of Group III, the most widely applied is the time for restoration following a failure of the DSO fuse (or, in Italy where the fuse is not owned by the DSO, the standard applied in case of failure of the meter if it provokes an interruption). In some cases, this standard depends on the customers' geographic location, the voltage level, the time of call (daytime or night-time) and on whether the customer possesses any electronic medical device needed for survival.

Coping with voltage complaints normally involves two steps: the first step in the remedy of voltage complaints is to verify, through necessary measurements and investigations, whether any regulations or standards in force have been violated. The second step of the remedy is the correction of voltage problems through appropriate works on the networks.

It is important that any customer problem related to voltage disturbance is rectified without undue delay (i.e. as soon as possible). Part of this includes implementing temporary measures when and where appropriate. The exact time needed to rectify the problem or to implement temporary solutions will vary a lot and depends upon the complexity of the given situation. (See also Chapter 3 on voltage quality for more information about regulations and standards in force in different countries). For this reason, the voltage complaint second-step indicator is not reported in Table 4.10.

TABLE 4.10 COMMERCIAL QUALITY STANDARDS FOR TECHNICAL CUSTOMER SERVICE

Quality indicator (Group III)	**Countries** (grouped by type of standard)	**Standards**[1] (median value and range)	**Compensation**[2] (median value, only GS)	**Company involved**
Time for giving information on a planned interruption	**GS:** CY, CZ, ES, HU, UK **OS:** AT, BE(Walloon), EE, SI **OAR:** IT, LT, LU, LV, NO	2 days (range: 1-20)	€ 20	DSO
Restoration time in the case of failure of DSO fuse	**GS:** CY, CZ, HU, IT[3], PT, UK, **OS:** BE(Walloon) **OAR:** BE(Flemish), LT, LV, NO, SI	4 hours (range: 2-24)	€ 20	DSO
Time for answering voltage complaints	**GS:** CY, CZ, HU, IT[4], PT, UK, **OS:** RO **OAR:** BE(Flemish), LT, LV, NO, SI	15 working days (range 8-120)	€ 20	DSO

Legend: GS guaranteed standards; OS overall standards; OAR: other available requirements
Notes
(1) when differentiated, only standards referred to LV customers have been considered
(2) when differentiated, only compensation applicable to household customers has been considered
(3) applicable to failure of the meter if it provokes an interruption of supply
(4) enforced as GS from 2008; OS until 2007

4.3.4 Group IV: Metering and billing

Group IV includes a set of commercial quality indicators related to metering and billing. The following indicators have been considered:

- Time for inspection in case of meter failure (Annex 3, Table CQ 1.13);
- Yearly number of meter readings by the designated company (Annex 3, Table CQ 1.14);
- Time from notice-to-pay until disconnection (Annex 3, Table CQ 1.15 and CQ 1.16);
- Time for restoration of power supply following disconnection due to non-payment (Annex 3, Tables CQ 1.17 and CQ 1.18).

Table 4.11 summarises responses on commercial quality indicators of Group IV that refer mainly to DSOs for metering and to SP/USP for billing. Other indicators are in use in individual countries (for instance, time for correction of prepayment meters and the allowed proportion of meters with expired calibration).

In general, only a few regulators dictate standards in connection with meters. Regarding the duration of an inspection of a meter failure, the typical standard in use is between 5 and 10 days. The standard duration for the correction of prepayment meters is set in only two cases. It should be taken into consideration that with the proliferation of smart meters the authentication time will be shortened and, mainly in the start-up period of the change over, the frequency of meter failures might increase. The licensee should be prepared for quick corrections to avoid paralysis in invoicing.

In most cases, the typical number of annual meter readings is one, although there are significant differences depending on the size of the customer. For instance, in Norway the regulator has set out in regulations that meters shall be read at least once a year, but as regards end-users with an annual consumption above 8,000 kWh, meters shall be read monthly, bi-monthly or quarterly (periodic readings). Furthermore, the meters shall be read at every turn of the year. In Spain, at least six readings must be done. This indicator will be important until the inflow of smart meters. With the roll-out of smart metering, the licensee will have the opportunity to make out invoices based on the monthly data read from the smart meters.

For Group IV, the standard for the time for restoration of power supply following disconnection due to non-payment attracted the most attention among the responding NRAs. This standard is closely connected to the availability of the service. Consumers who have settled their debts and paid all fees in connection with the disconnections can demand to be reconnected to electricity as soon as possible. This right is respected by the regulators, i.e. this is one of the most prevalently used indicators with an overly small (short) expected value.

TABLE 4.11 COMMERCIAL QUALITY STANDARDS FOR METERING AND BILLING

Quality indicator (Group IV)	Countries (grouped by type of standard)	Standards[(1)] (median value and range)	Compensation[(2)] (median value , only GS)	Company involved
Time for meter inspection in case of meter failure	**GS:** HU, IT[(4)], SI[(3)], **OS:** RO **OAR:** BE(Flemish), EE, LT, PL	10 working days (range 5-23)	€ 20	DSO
Yearly number of meter readings by the designated company	**GS:** PT **OS:** AT, ES, HU **OAR:** CY, IT, NO, PL, SE, SI[(3)]	at least 1 reading/year (range: 1-12)	€ 18	DSO
Time from notice-to-pay until disconnection	**GS:** none **OS:** AT, ES, HU, RO **OAR:** BE(Flemish), CY, IT, LT, LU, LV, NO, PL, PT, SE, SI	14 working days (range 2-90)	N/A	DSO
	GS: none **OS:** AT, HU, RO **OAR:** EE, IT, LT, LU, LV, PL, SE, SI	14 working days (range 8-90)	N/A	SP/USP
Time for restoration of power supply following disconnection due to non-payment	**GS:** CZ, HU, ES, IT, PT **OS:** AT **OAR:** BE(Flemish), CY, LT, LU, LV, PL, SI	2 days (range 1-5)	€ 25	DSO
	GS: CZ, HU **OS:** RO **OAR:** AT, EE, LV, LU, PL, SI	2 days (range 1-5)	€ 20-40	SP/USP
Time for solving billing complaints	**GS:** HU, IT, LV	15 days (range 15-90)	€ 20-30	SP
	GS: HU, IT, LV, PT **OS:** EE	15 days (range 15-90)	€ 25	USP

Legend: GS guaranteed standards; OS overall standards; OAR: other available requirements
Notes
(1) when differentiated, only standards referred to LV customers have been considered
(2) when differentiated, only compensation applicable to household customers has been considered
(3) regulatory proposal, currently under consultation
(4) enforced as GS from 2008; OS until 2007

4.4 The Challenge for Commercial Quality due to Full Market Opening

This section describes full market opening from the commercial quality point of view; an issue not covered in previous benchmarking reports. NRAs were asked to reply whether there are any standards for routine procedures to switch supplier or to amend a contract (DSOs and SPs, as well as USPs are handled separately in this analysis). Respondents were also requested to briefly explain their answers, for both negative and positive answers. In the sections below, there is a summary of the findings, together with some statistics on the answers.

4.4.1 Statements concerning Distribution System Operators

The most frequent requirement for standard procedures to switch supplier or to amend a contract is the transfer of information from the DSO to the new SP. This is the only requirement valid for the majority of DSOs. This requirement is monitored using the time elapsed until a customer's notice on switching supplier is replied to and the time elapsed until disconnection upon supplier's request due to customer's non-payment. About a third of the respondents stated that the option to choose between network tariffs (at DSOs) was also a requirement. Almost all responding regulators reported that (in the case of DSOs) debt handling in the context of supplier switching is not regulated by standards.

TABLE 4.12 REQUIREMENTS RELATED TO MARKET OPENING UPON DSOs

Standards Applied - DSO	Austria	Belgium-Walloon	Czech Republic	Denmark	Finland	Germany	Hungary	Latvia	Luxembourg	Norway	Poland	Portugal	Romania	Slovenia	Spain	Sweden	YES, Total	NO, Total
V. 20. Response time, notice	●	●	✓	●	●	✓	●	✓	●	●	✓	●	●	●	✓	✓	6	10
V. 21. Non-payment patience	●	●	●	●	✓	●	●	✓	●	●	✓	✓	✓	●	✓	✓	7	9
V. 22.a. Debt handling	●	●	●	●	●	●	●	●	●	●		✓	✓	●	●	●	2	13
V. 22.b. Information transfer	✓	●	✓	●	●	✓	●	✓	●	✓	✓	✓	✓	●	✓	✓	10	6
V. 22.c. Tariff options	●	●	✓	●	●	●	●	✓	●	✓	✓		●	●	✓	●	5	10
YES, Total	1	0	3	0	1	2	0	4	0	2	4	3	3	0	4	3	**30**	
NO, Total	4	5	2	5	4	3	5	1	5	3	0	1	2	5	1	2		**48**

✓ means YES, ● means NO and empty cells mean "no answer"

4.4.2 Statements concerning Supply Providers

Based on the respondents' reports, the most prevalently applied requirements for standard procedures to switch supplier and/or to amend a contract are the publication of tariffs by suppliers and meter reading. Information transfer from the DSO to the new SP and the time until disconnection due to customer's non-payment can be perceived as well-standardised requirements as well. Similarly to the results derived from replies concerning DSOs, debt handling in cases of supplier switching is not a standardised requirement. In general, there is no requirement that is applied by the majority of countries.

TABLE 4.13 REQUIREMENTS RELATED TO MARKET OPENING UPON SPs

Standards Applied - SP	Austria	Czech Republic	Denmark	Finland	Hungary	Latvia	Luxembourg	Norway	Poland	Portugal	Romania	Slovenia	Sweden	YES, Total	NO, Total
V. 20. Response time, notice	●	✓	●	●	●	✓	●	●	●			●	✓	3	8
V. 21. Non-payment patience	●		●	●	●	✓		●	✓	✓	✓	●	✓	5	6
V. 22.a. Debt handling	●	●	●	●	✓	●		●				●	●	1	8
V. 22.b. Information transfer	✓	✓	●	●	●	✓	●	✓	●			●	✓	5	6
V. 22.c. Tariff publication	✓	✓	✓	✓	✓	✓	●	✓	●	✓		●	✓	9	3
V. 22.d. Termination time	●		●	✓	✓	✓	●	●	●			●	●	3	7
V. 22.e. Termination day	●		●		✓	✓	●	●				●	●	2	6
V. 22.f. Meter reading	✓	✓	●	●	✓	●	●	✓	●	✓		●	✓	6	6
YES, Total	3	4	1	2	5	6	0	3	1	3	1	0	5	**34**	
NO, Total	5	1	7	5	3	2	6	5	5	0	0	8	3		**50**

✓ means YES, ● means NO and empty cells mean "no answer"

4.4.3 Statements concerning Universal Service Providers

The responses received show that publication of tariffs by suppliers is the only standardised requirement in standard procedures to switch supplier or to amend contract valid in the majority of the USPs.

TABLE 4.14 REQUIREMENTS RELATED TO MARKET OPENING UPON USPs

Standards Applied - USP	Austria	Czech Republic	Denmark	Estonia	Hungary	Latvia	Luxembourg	Poland	Portugal	Romania	Slovenia	YES, Total	NO, Total
V. 20. Response time, notice		✓	●		●	✓	●	●	●	●	●	2	7
V. 21. Non-payment patience			●	●	●	✓		✓	✓	✓	●	4	4
V. 22.a. Debt handling		●	●	●	●	●	✓		✓	✓	●	3	6
V. 22.b. Information transfer	✓	✓	●		●	✓	●	●	●		●	3	6
V. 22.c. Tariff publication		✓	✓	✓	●	✓	●	✓	✓	✓	●	7	3
V. 22.d. Termination time			●		✓	✓	●	●	●	✓	●	3	5
V. 22.e. Termination day			●		✓	✓	●		●	✓	●	3	4
V. 22.f. Meter reading		✓	●		✓	●	●	●	✓	✓	●	4	4
YES, Total	1	4	1	1	3	6	1	2	4	6	0	**29**	
NO, Total	0	1	7	2	5	2	6	4	4	1	8		**39**

✓ means YES, ● means NO and empty cells mean "no answer"

4.5 Conclusions and Recommendations on Commercial Quality

4.5.1 Summary of benchmarking results

Table 4.15, Table 4.16 and Table 4.17 below integrate the information given in the tables from sections 4.1, 4.2 and 4.3 of the report. They show the number of countries where each commercial quality standard is in force per type of standard, for DSOs (Table 4.15), for SPs (Table 4.16) and for USPs (Table 4.17).

Standards for DSOs are in force in a minimum of 7 countries (Punctuality of appointments with customers, time for meter inspection in case of meter failure) up to a maximum of 15 countries (time from notice-to-pay until disconnection).

For SPs and USPs, only three standards are in force (the same standards for both SPs and USPs) in around 15-25% of the countries.

TABLE 4.15 NUMBER OF COUNTRIES WHERE COMMERCIAL QUALITY STANDARDS ARE IN FORCE PER TYPE OF STANDARD (DSOs)

Standard for DSOs	Guaranteed standard (GS)	Overall standard (OS)	Other available requirement (OAR)	Total
Cost estimation for connection	6	4	2	12
Punctuality of appointments with customers	7			7
Response time to customer complaints in written form	5	1	6	12
Response time to customer queries in written form	3	3	4	10
Response time, queries on costs and payments	4	3	3	10
Time between signing contract and the start of supply	4	3	3	10
Time for meter inspection in case of meter failure	3		4	7
Time for response to customer claims for network connection	5	5	3	13
Time for connecting new LV customers	4	3	4	11
Time from notice-to-pay until disconnection		4	11	15
Time for answering the voltage complaint	6	1	5	12
Time for restoration of power supply following disconnection due to non-payment	5	2	7	14
Time until restoration following failure of DSO fuse	6	1	4	11
Yearly number of meter readings by the designated company	1	3	7	9
Time for giving information on a planned interruption	5	4	4	14

TABLE 4.16 NUMBER OF COUNTRIES WHERE COMMERCIAL QUALITY STANDARDS ARE IN FORCE PER TYPE OF STANDARD (SPs)

Standard for SPs	Guaranteed standard (GS)	Overall standard (OS)	Other available requirement (OAR)	Total
Response time to customer complaints in written form	2	2	2	6
Time from notice-to-pay until disconnection		3	5	8
Time for restoration of power supply following disconnection due to non-payment	2	1	4	7

TABLE 4.17 NUMBER OF COUNTRIES WHERE COMMERCIAL QUALITY STANDARDS ARE IN FORCE PER TYPE OF STANDARD (USPs)

Standard for USPs	Guaranteed standard (GS)	Overall standard (OS)	Other available requirement (OAR)	Total
Response time to customer complaints in written form	3	3	2	8
Time from notice-to-pay until disconnection		2	6	8
Time for restoration of power supply following disconnection due to non-payment	2	1	5	8

4.5.2 Final conclusions and recommendations

1. Quality Regulations and Content of Indicators

Based on the responses to the questionnaire, a first conclusion is that NRAs devote great attention to the commercial quality of the services provided for customers. At the same time, it is apparent that there are significant differences between member countries concerning the nature and the number of indicators applied. At the time of the 3rd Benchmarking Report, there were hardly any commercial quality parameters regulated in the same way across the CEER member countries. The present survey revealed that the number of identical (or at least partially identical) regulation concerning these standards has grown considerably. Before the next Benchmarking Report, some terms should be clarified; otherwise analysis may easily lead to erroneous conclusions.

2. Ways of regulating commercial quality

Commercial quality indicators can be used by regulators in three ways: the regulator has the option either to define OSs, that normally are not linked to economic effects (aside from some countries where the regulator can impose sanctions, in the form of penalties or price reductions, upon companies not fulfilling the OSs); or to use GSs, by which customers receive direct compensation if standards are not met. The third way is to determine regulatory requirements (OARs) and in case they are not met sanctions can be imposed by the regulator. Regulators' activities show that there is a general trend over time to move from OSs to GSs for those countries using OSs and GSs. CEER recommends member countries consider the usefulness of GSs tied to direct automatic compensation for quality parameters or other regulatory requirements with the possibility to impose sanctions for non-compliance, wherever information on the particular parameter makes it possible.

3. Ensuring the Availability of the Service

For all types of licensees, it is clear from this benchmarking that the most frequently applied standards are aiming at either restoring the supply as fast as possible after a disconnection due to non-payment or at connecting new customers as fast as possible. The CEER finds this regulatory priority meets customer expectations as its purpose is to maximise the availability of the service.

4. New Fields of Regulation upon Technological Development

During recent years (due to the development of the telecommunications sector), a restructuring of the ways for maintaining contact with customers (mainly mobile communication) could be observed. In the place of personal and written contacts, major relevance is taken by call centres, and there is a growing need for the possibility of on-line administration.

Concerning this new issue, regulations are still in their infancy. Customer service does not only mean answering and settling of phone complaints in a timely manner; it also means getting in touch with the customer service agent without repeated phone calls and, in any case, having a short waiting time. The CEER recommends that NRAs consider developing procedures capable of measuring the performance of call centres, and monitor the performance of the licensees in order to establish regulations that fall within their legal powers.

5. Exploiting the Opportunities Provided by Technological Development

Having accurate billing, based on the actual, measured consumption even if it is preliminary, is becoming more and more important both for customers and licensees. Recognising this need, many countries have launched programmes aiming at collecting monthly (or even more frequent) meter data without 'bothering' customers with readings. Smart meters are being put in practice in a number of countries. This technical development might contribute to decrease the billing complaints and can ease and shorten the procedure of supplier switching.

From the viewpoint of improving commercial quality, CEER welcomes the spread of smart meters. It allows increasing productivity, such that DSOs can dispense with scheduling meter reading appointments for most works that require access to the meter, when the meter is inside the customer's house. Remote control systems allow the DSO to obtain readings without visiting the customer, to increase or decrease connection power and finally to interrupt the supply in case of non-payment and to restore it quickly after payment. Customers can further benefit from the introduction of smart meters as they can inter alia get information on their consumption profile or guidance regarding the off-peak (cheaper) supply periods.

6. Effects of Unbundling

From the responses received, it is evident that the division of energy companies into DSOs and SPs/USPs (unbundling) is complete. In countries where competition works properly, the regulatory authorities monitor distributors' activities in a much larger proportion than suppliers' activities: the CEER regulators apply fewer standards for SPs and USPs than for DSOs. Furthermore, in countries with stated requirements, these are identical for both types of licensees. Where markets work properly and efficiently, we find that for the SP only limited regulation is reasonable in the long run, while in connection with the USP the level of service provided for the authority-regulated price has to be defined accurately.

7. The Regulation of Market Opening

This was the first time the regulation of activities regarding market opening and supplier switching was surveyed with regard to commercial quality with a separate and thematic group of questions. It is clear that the importance of the availability of information has increased with liberalisation. In a well-functioning market, it is indispensable that all participants have enough and credible information - taking both advantages and drawbacks into consideration - as this is the only way that well-supported decisions can be made. As we have seen in the world of telecommunications, a licensee can raise a number of administrative barriers when a customer wishes to leave (switch). In brief, it is important to have valid regulations that define the exact conditions of supplier switching.

ANNEXES

Annex 1: Annex to Chapter 2 on Continuity of Supply

Tables CoS 2.1-CoS 2.10 contained in this Annex correspond to the figures (with the same numbering) in Chapter 2 on Continuity of Supply. Tables CoS 2.11 - CoS 2.12 correspond to the figures (with the same numbering) in this Annex.

TABLE COS 2.1 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; MINUTES LOST PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria HV, MV				35.23	38.44	30.33	31.35	48.07	45.50
Czech Republic									
Denmark HV, MV								22.20	21.70
Estonia HV, MV, LV					12.13				
Finland MV (20kV)									
France HV, MV, LV	52.00	46.00	39.00	40.00	51.00	50.70	52.20	71.50	57.70
Germany HV, MV, LV								21.53	
Hungary HV, MV, LV									
Iceland HV, MV, LV	127.98	105.05	78.57	51.09	49.69	54.71	127.18	106.17	77.93
Italy HV, MV, LV			138.57	108.88	96.88	76.52	65.74	53.84	52.47
Latvia HV, MV, LV									
Lithuania HV, MV, LV							92.39	89.28	92.21
the Netherlands HV, MV, LV									
Norway HV, MV									
Poland HV, MV, LV									
Portugal HV, MV, LV			412.86	334.54	303.75	148.81	142.82	152.08	102.54
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV	156.37	145.41	179.69	142.56	141.91	123.60	117.00	112.80	103.80
Sweden HV,MV, LV									
UK HV, MV, LV			73.80	72.24	68.16	61.43	61.04	89.43	

TABLE COS 2.2 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria HV, MV				0.59	0.67	0.61	0.67	0.87	0.77
Czech Republic									
Denmark HV, MV								0.42	0.43
Estonia HV, MV, LV					0.15		1.58	1.56	2.12
Finland MV (20kV)									
France HV, MV, LV(1)	1.20	1.20	1.20	1.15	1.40	1.30	1.02	1.30	0.98
Germany HV, MV, LV								0.46	
Hungary HV, MV, LV									
Iceland HV, MV, LV	1.18	1.32	2.10	0.92	1.34	0.64	1.44	1.56	2.22
Italy HV, MV, LV			3.19	2.74	2.68	2.42	2.33	2.23	2.10
Latvia HV, MV, LV									
Lithuania HV, MV, LV							1.02	1.05	1.19
the Netherlands HV, MV, LV									
Norway HV, MV									
Poland HV, MV, LV									
Portugal HV, MV, LV			5.90	5.93	4.81	2.69	2.71	2.73	2.03
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV			3.30	2.65	2.60	2.52	2.31	2.38	2.23
Sweden HV,MV, LV									
UK HV, MV, LV			0.83	0.75	0.77	0.69	0.71	0.84	

(1) France: since 2004, SAIFI calculation is based on interruptions of MV/LV substations, instead of interruptions of feeders

TABLE COS 2.3 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS, EXCLUDING PORTUGAL - MINUTES LOST PER YEAR (1999-2007)

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Mean + std dev	166.07	148.81	158.24	125.38	114.72	103.13	117.14	106.26	97.48
Mean	112.11	98.82	101.92	82.95	69.96	73.39	85.92	70.84	67.63
Mean – std dev	58.15	48.82	45.60	40.52	25.19	43.65	54.70	35.42	37.78

TABLE COS 2.4 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS, EXCLUDING PORTUGAL- NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Mean + std dev			3.24	2.61	2.48	2.42	2.12	2.01	2.34
Mean			2.12	1.64	1.49	1.51	1.48	1.31	1.61
Mean – std dev			1.00	0.66	0.49	0.60	0.84	0.61	0.87

TABLE COS 2.5	UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; MINUTES LOST PER YEAR (1999-2007)								
Country	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Austria HV, MV(1)				83.08	38.44	30.33	39.41	48.49	72.00
Czech Republic									
Denmark HV, MV(2)								23.00	24.40
Estonia HV, MV, LV					20.77	41.91	458.02	259.53	196.57
Finland MV (20kV)	172.50	115.60	258.20	139.80	124.30	104.70	181.65	147.10	106.45
France HV, MV, LV(3)	55.00	46.00	59.00	52.00	69.30	57.10	55.90	86.30	61.60
Germany HV, MV, LV								23.25	
Hungary HV, MV, LV	411.00	241.20	250.20	196.80	155.40	137.40	121.80	127.70	130.78
Iceland HV, MV, LV	127.98	105.05	78.57	51.09	49.69	54.71	127.18	106.17	77.93
Italy HV, MV, LV	191.77	187.40	149.09	114.74	546.08	90.53	79.86	60.55	57.89
Latvia HV, MV, LV									269.00
Lithuania HV, MV, LV							373.57	168.70	301.70
the Netherlands HV, MV, LV	26.00	27.00	34.00	28.00	30.00	24.00	27.40	35.60	33.10
Norway HV, MV							90.00	114.00	96.00
Poland HV, MV, LV									409.99
Portugal HV, MV, LV			530.74	467.98	406.18	217.79	198.73	243.19	136.21
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV	156.37	145.41	179.69	142.56	141.91	123.60	117.00	112.80	103.80
Sweden HV,MV, LV	165.77	89.17	162.90	101.84	148.05	78.08	913.50	99.60	300.40
UK HV, MV, LV			75.84	101.33	72.68	87.33	61.04	89.43	

(1) Austria: 2002 approximation value
(2) Denmark: 2006 excl. LV
(3) France: calculations are weighted by the number of customers for LV

TABLE COS 2.6 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria HV, MV				0.77	0.67	0.61	0.69	0.89	0.90
Czech Republic									
Denmark HV, MV(1)								0.42	0.46
Estonia HV, MV, LV					0.62	0.35	1.63	1.58	2.12
Finland MV (20kV)	6.09	4.87	6.25	4.57	4.86	4.34	5.82	6.27	5.17
France HV, MV, LV(2)	1.22	1.20	1.20	1.20	1.43	1.30	1.08	1.33	0.98
Germany HV, MV, LV								0.46	
Hungary HV, MV, LV	3.09	2.29	2.13	2.03	2.05	1.90	1.77	1.79	1.83
Iceland HV, MV, LV	1.18	1.32	2.10	0.92	1.34	0.64	1.44	1.56	2.22
Italy HV, MV, LV	3.81	3.59	3.29	2.76	3.96	2.48	2.42	2.29	2.16
Latvia HV, MV, LV									2.18
Lithuania HV, MV, LV							1.74	1.65	2.18
the Netherlands HV, MV, LV	0.40	0.40	0.40	0.30	0.40	0.30	0.30	0.45	0.33
Norway HV, MV							1.50	1.80	1.70
Poland HV, MV, LV									3.09
Portugal HV, MV, LV			7.51	7.35	5.96	3.66	3.54	3.81	2.62
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV			3.30	2.65	2.60	2.52	2.31	2.38	2.23
Sweden HV,MV, LV	1.38	1.23	1.34	1.32	1.64	1.10	1.49	1.28	1.50
UK HV, MV, LV			0.84	0.82	0.79	0.75	0.71	0.84	

(1) Denmark: 2006 excl. LV
(2) France: calculations are weighted by the number of customers for LV

TABLE COS 2.7 PLANNED INTERRUPTIONS: MINUTES LOST PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria HV, MV				7.40	12.79	20.70	20.97	22.38	18.77
Czech Republic									
Denmark HV, MV(1)								3.00	4.70
Estonia HV, MV, LV					24.38	20.42	197.05	123.54	217.47
Finland MV (20kV)	103.00	38.00	33.00	32.00	32.00		16.00	26.00	31.80
France HV, MV, LV(2)	4.00	6.00	6.00		5.30	6.60	8.00	7.90	10.80
Germany HV, MV, LV								15.10	
Hungary HV, MV, LV		100.06	139.58	137.02	199.24	178.95	138.50	139.97	145.00
Iceland HV, MV, LV	47.28	51.28	17.07	20.78	56.60	14.65	27.78	55.55	11.93
Italy HV, MV, LV		82.62	84.82	77.97	80.67	62.62	58.77	53.79	46.16
Latvia HV, MV, LV									237.00
Lithuania HV, MV, LV							113.62	98.27	71.23
the Netherlands HV, MV, LV								2.81	3.34
Norway HV, MV(3)							42.00	42.00	48.00
Poland HV, MV, LV									121.02
Portugal HV, MV, LV			57.37	52.21	62.39	49.16	39.16	18.70	7.31
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV	31.36	37.05	36.57	30.66	24.79	21.60	13.80	9.60	11.40
Sweden HV,MV, LV	90.07	34.53	42.28	37.12	25.41	24.83	33.42	23.81	23.14
UK HV, MV, LV			7.85	9.04	8.43	6.95	8.12	10.67	

(1) Denmark: 2006 excl. LV
(2) France: For MV and LV special interruptions were planned in 2007 to eliminate PCB transformers
(3) Norway: No incidents at LV, but LV customers are included

TABLE COS 2.8 PLANNED INTERRUPTIONS: NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria HV, MV				0.07	0.13	0.17	0.18	0.19	0.19
Czech Republic									
Denmark HV, MV(1)								0.03	0.05
Estonia HV, MV, LV					0.49	0.002	0.72	0.50	0.48
Finland MV (20kV)	1.80	1.30	0.60	0.50	0.50		1.00	0.60	0.76
France HV, MV, LV(2)	0.03	0.04	0.04		0.04	0.05	0.06	0.06	0.11
Germany HV, MV, LV								0.12	
Hungary HV, MV, LV		0.35	0.55	0.54	0.74	0.68	0.54	0.57	0.56
Iceland HV, MV, LV	0.24	0.29	0.12	0.13	0.13	0.08	0.12	0.19	0.11
Italy HV, MV, LV		0.61	0.59	0.49	0.49	0.40	0.37	0.34	0.30
Latvia HV, MV, LV									0.27
Lithuania HV, MV, LV							0.40	0.36	0.25
the Netherlands HV, MV, LV								0.02	0.02
Norway HV, MV(3)							0.30	0.30	0.30
Poland HV, MV, LV									0.38
Portugal HV, MV, LV			0.32	0.29	0.30	0.23	0.19	0.09	0.04
Romania									
Slovak Republic									
Slovenia MV									
Spain HV, MV, LV			0.42	0.26	0.20	0.19	0.09	0.08	0.09
Sweden HV,MV, LV	0.45	0.25	0.23	0.26	0.22	0.18	0.22	0.25	
UK HV, MV, LV			0.04	0.04	0.04	0.03	0.04	0.04	

(1) Denmark: 2006 excl. LV
(2) France: For MV and LV special interruptions were planned in 2007 to eliminate PCB transformers
(3) Norway: No incidents at LV, but LV customers are included

TABLE COS 2.9 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; MINUTES LOST PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium MV urban			39.85	31.45	25.02	23.03	22.13	22.73	
France LV urban			26.00			22.00	30.00	32.00	
France LV suburban			53.00			40.00	45.00	50.00	
France LV rural			93.00			91.00	80.00	125.00	
Italy HV, MV, LV urban	86.71	84.33	71.23	54.66	53.01	41.31	43.70	42.40	48.28
Italy HV, MV, LV suburban	149.09	170.19	152.58	112.32	90.67	72.21	63.71	58.13	65.65
Italy HV, MV, LV rural	282.47	229.18	193.70	170.97	165.11	129.82	98.57	73.03	77.79
Lithuania HV, MV, LV urban							33.29	26.84	29.49
Lithuania HV, MV, LV rural							58.92	62.43	62.73
Portugal HV, MV, LV urban			154.98	130.86	145.23	82.73	92.99	98.08	52.00
Portugal HV, MV, LV suburban			256.19	260.23	231.29	120.52	115.68	112.17	72.18
Portugal HV, MV, LV rural			637.53	475.48	429.72	201.64	183.32	206.39	149.00
Spain HV, MV, LV urban					88.20	83.40	81.60	67.80	69.00
Spain HV, MV, LV suburban					166.20	126.60	123.00	119.40	105.00
Spain HV, MV, LV rural					264.60	228.55	197.52	222.16	196.97

TABLE COS 2.10 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium MV urban			0.66	0.51	0.58	0.46	0.55	0.42	
France LV urban			0.99			0.90	0.72	0.80	
France LV suburban			1.28			1.23	1.05	1.20	
France LV rural			1.34			1.60	1.30	1.80	
Italy HV, MV, LV urban	1.95	1.92	1.91	1.59	1.65	1.42	1.55	1.68	1.71
Italy HV, MV, LV suburban	3.68	3.46	3.13	2.71	2.55	2.41	2.33	2.35	2.48
Italy HV, MV, LV rural	6.33	5.27	4.81	4.21	4.19	3.79	3.30	3.08	2.74
Lithuania HV, MV, LV urban							0.48	0.44	0.54
Lithuania HV, MV, LV rural							0.80	0.60	0.68
Portugal HV, MV, LV urban			2.53	2.53	2.33	1.66	1.79	1.48	1.23
Portugal HV, MV, LV suburban			4.41	4.67	3.98	2.32	2.43	2.28	1.60
Portugal HV, MV, LV rural			8.43	8.19	6.86	3.63	3.39	3.81	2.90
Spain HV, MV, LV urban					1.97	1.98	1.73	1.74	1.64
Spain HV, MV, LV suburban					3.04	2.62	2.51	2.56	2.40
Spain HV, MV, LV rural					3.96	3.81	3.40	3.76	3.50

TABLE COS 2.11 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; PER VOLTAGE LEVEL; MINUTES LOST PER YEAR (1999-2007)

Country	Voltage Level	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	MV				35.23	38.44	30.33	31.35	48.07	45.50
Brussels Region	HV					14.50	3.18	22.40	0.12	
Brussels Region	MV			39.85	31.45	25.02	23.03	22.13	22.73	
Denmark	HV								2.30	3.50
Denmark	MV								19.90	18.20
Denmark	LV									1.70
Estonia	T					5.88	1.84	5.40	4.75	7.47
Estonia	MV					21.12	42.86	468.80	265.60	201.30
France	HV	2.00	1.90	2.90	1.90	2.20	1.50	6.70	7.50	2.10
France	MV	42.00	36.00	28.00	31.00	40.00	41.00	37.00	55.00	47.00
France	LV	8.00	8.00	8.00	7.00	9.00	9.00	9.00	9.00	9.00
Germany	MV								18.67	
Germany	LV								2.86	
Hungary	HV					4.11	1.45	1.29	2.42	0.37
Hungary	MV		163.51	174.36	139.24	104.96	99.72	83.77	86.36	98.48
Hungary	LV		77.69	75.84	57.56	46.33	40.43	36.75	38.91	40.82
Iceland	T	79.95	77.56	53.06	27.12	34.36	31.07	110.16	89.59	66.57
Iceland	HV	79.95	77.56	53.06	27.12	34.36	31.07	110.16	89.59	66.57
Iceland	MV	46.01	26.12	24.28	22.44	13.29	21.95	14.33	16.04	10.59
Iceland	LV	2.02	1.37	1.23	1.53	2.04	1.69	2.70	0.54	0.77
Italy	T	0.68	2.72	8.00	0.82	0.94	1.66	0.83	0.96	1.57
Italy	HV	1.15	2.63	2.12	1.46	1.66	2.80	1.99	1.26	1.82
Italy	MV	136.25	124.31	102.63	80.59	73.85	56.29	46.70	36.01	33.32
Italy	LV	26.44	29.56	25.82	26.01	20.38	15.76	15.61	15.61	15.76
Lithuania	HV							0.47	1.58	2.08
Lithuania	MV							67.18	62.15	65.20
Lithuania	LV							24.35	25.56	24.95
Spain	T					6.00	4.80	1.80	1.80	6.60
UK	HV				5.19	3.58	3.95	2.73	3.93	
UK	MV				49.18	45.62	40.92	36.04	42.90	
UK	LV				18.27	17.53	17.03	17.67	20.25	

TABLE COS 2.12 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; PER VOLTAGE LEVEL; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007)

Country	Voltage Level	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	MV				0.59	0.67	0.61	0.67	0.87	0.77
Brussels Region	HV					0.29	0.16	0.63	0.00	
Brussels Region	MV			0.66	0.51	0.58	0.46	0.55	0.42	
Denmark	HV								0.07	0.08
Denmark	MV								0.35	0.35
Denmark	LV									0.02
Estonia	T					0.14	0.06	0.15	0.15	0.19
Estonia	MV					0.15	0.35	1.66	1.61	2.17
France	T	0.09	0.09	0.09	0.07	0.14	0.09	0.06	0.08	0.08
France	HV						0.06	0.11	0.22	0.05
France	MV						0.94	0.86	1.04	0.88
France	LV						0.05	0.05	0.05	0.05
Germany	MV								0.43	
Germany	LV								0.02	
Hungary	HV					0.10	0.07	0.09	0.08	0.03
Hungary	MV		1.79	1.67	1.57	1.53	1.46	1.38	1.39	1.54
Hungary	LV	0.59	0.50	0.46	0.46	0.42	0.37	0.31	0.32	0.32
Iceland	T	0.74	0.98	1.80	0.64	1.15	0.42	1.20	1.30	2.02
Iceland	HV	0.74	0.98	1.80	0.64	1.15	0.42	1.20	1.30	2.02
Iceland	MV	0.43	0.33	0.29	0.28	0.18	0.22	0.23	0.25	0.20
Iceland	LV	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01
Italy	T	0.09	0.13	0.18	0.07	0.07	0.09	0.09	0.10	0.09
Italy	HV	0.10	0.12	0.14	0.10	0.09	0.11	0.12	0.09	0.13
Italy	MV	3.56	2.97	2.69	2.41	2.35	2.05	1.95	1.87	1.71
Italy	LV	0.23	0.24	0.18	0.16	0.17	0.17	0.16	0.16	0.17
Lithuania	HV							0.02	0.02	0.04
Lithuania	MV							0.80	0.79	0.90
Lithuania	LV							0.22	0.24	0.25
Spain	T					0.18	0.12	0.08	0.09	0.07
UK	HV				0.10	0.09	0.09	0.08	0.09	
UK	MV				0.54	0.55	0.51	0.48	0.54	
UK	LV				0.09	0.09	0.09	0.09	0.10	

The following figures, CoS 2.1 to CoS 2.10 (but excluding 2.3 and 2.4), present the same information as the matching Tables (with the same numbering) in Chapter 2 of the report, based on a logarithmic scale.

FIGURE COS 2.1 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; MINUTES LOST PER YEAR (1999-2007) - LOGARITHMIC SCALE

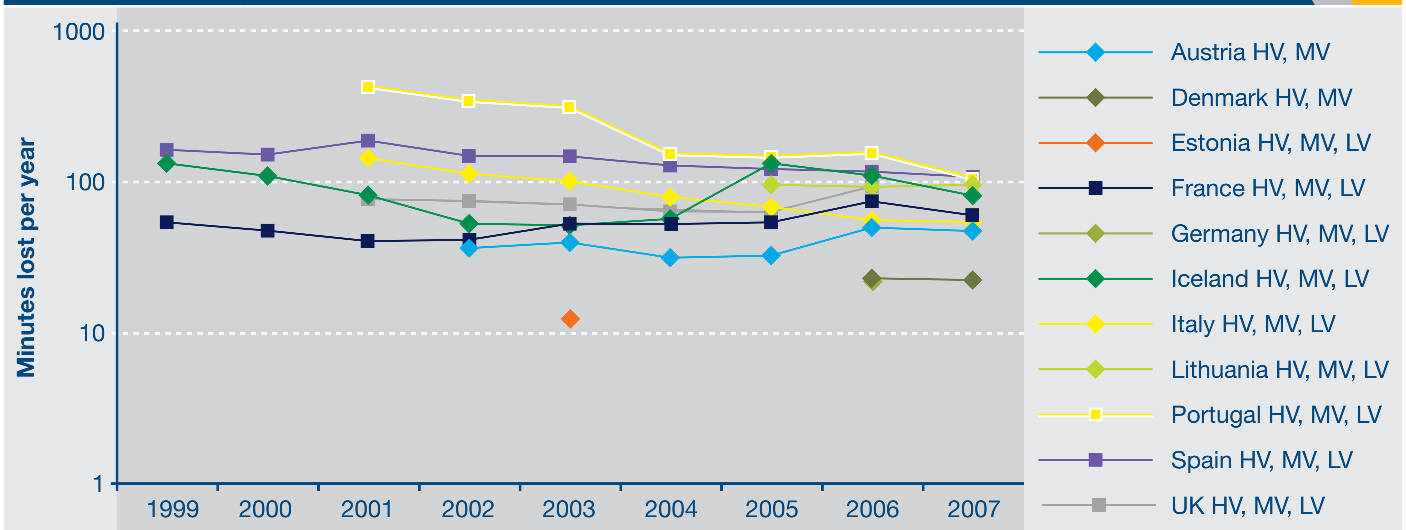


FIGURE COS 2.2 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) - LOGARITHMIC SCALE

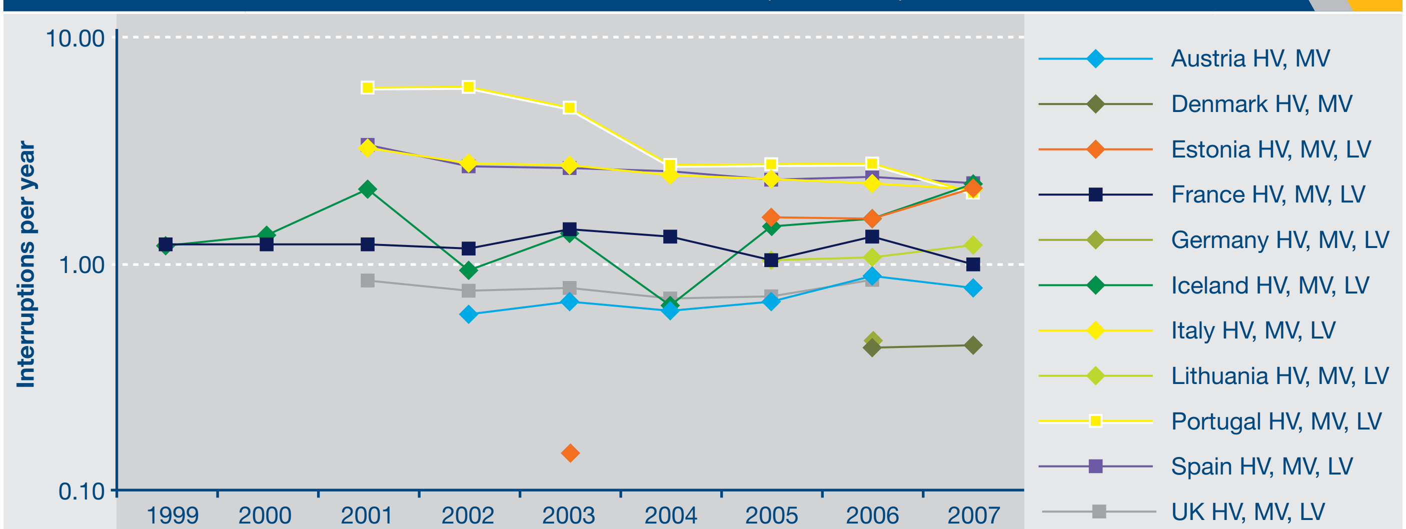


FIGURE COS 2.5 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; MINUTES LOST PER YEAR (1999-2007) - LOGARITHMIC SCALE

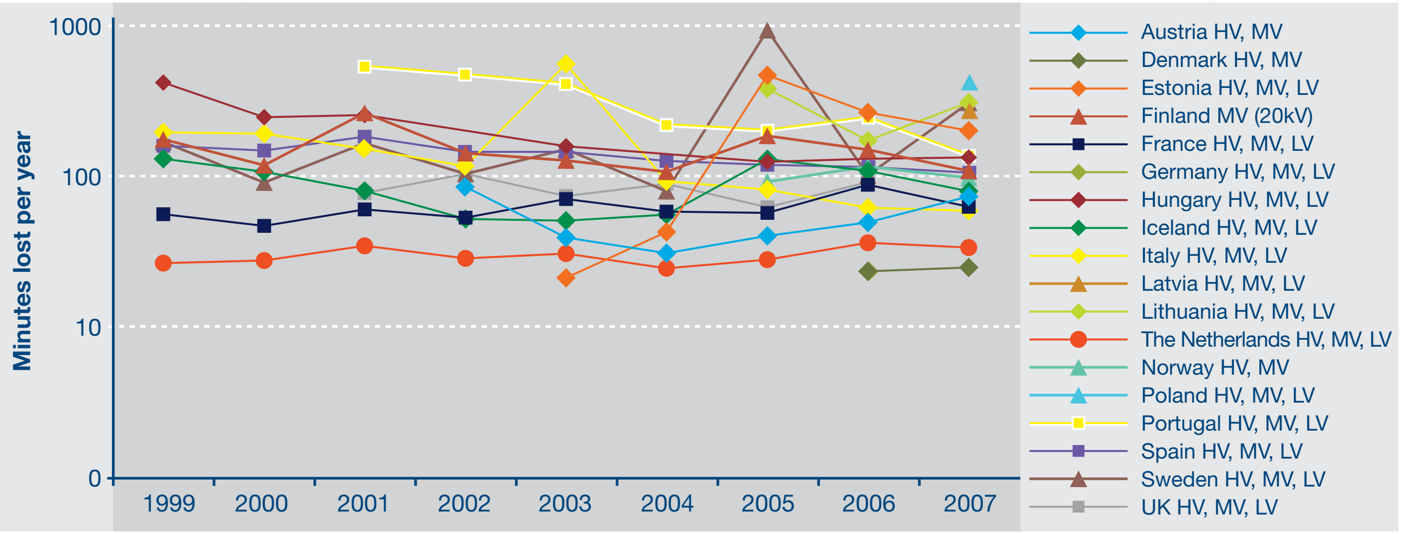


FIGURE COS 2.6 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) - LOGARITHMIC SCALE

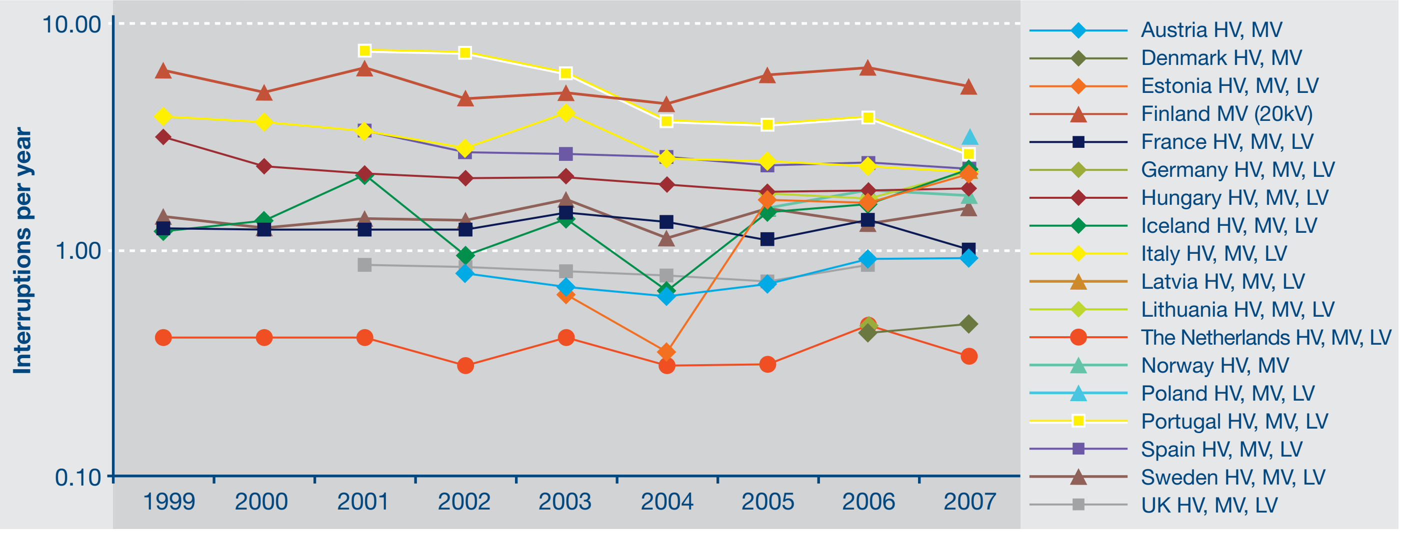


FIGURE COS 2.7 PLANNED INTERRUPTIONS;
MINUTES LOST PER YEAR (1999-2007) - LOGARITHMIC SCALE

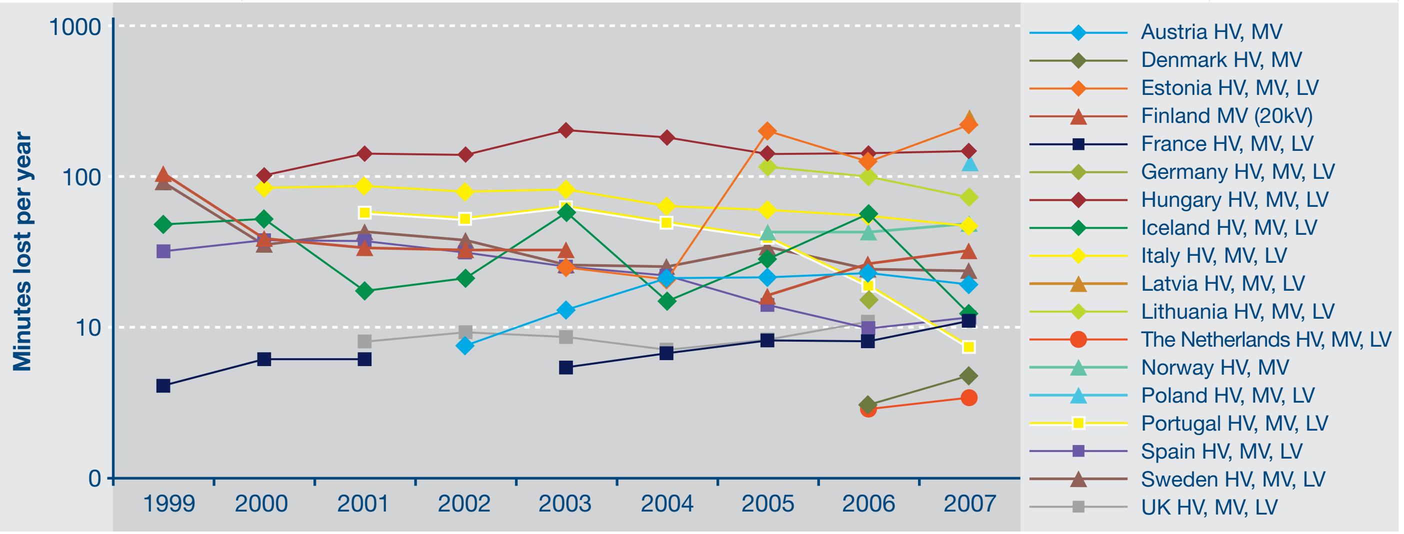


FIGURE COS 2.8 PLANNED INTERRUPTIONS;
NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) - LOGARITHMIC SCALE

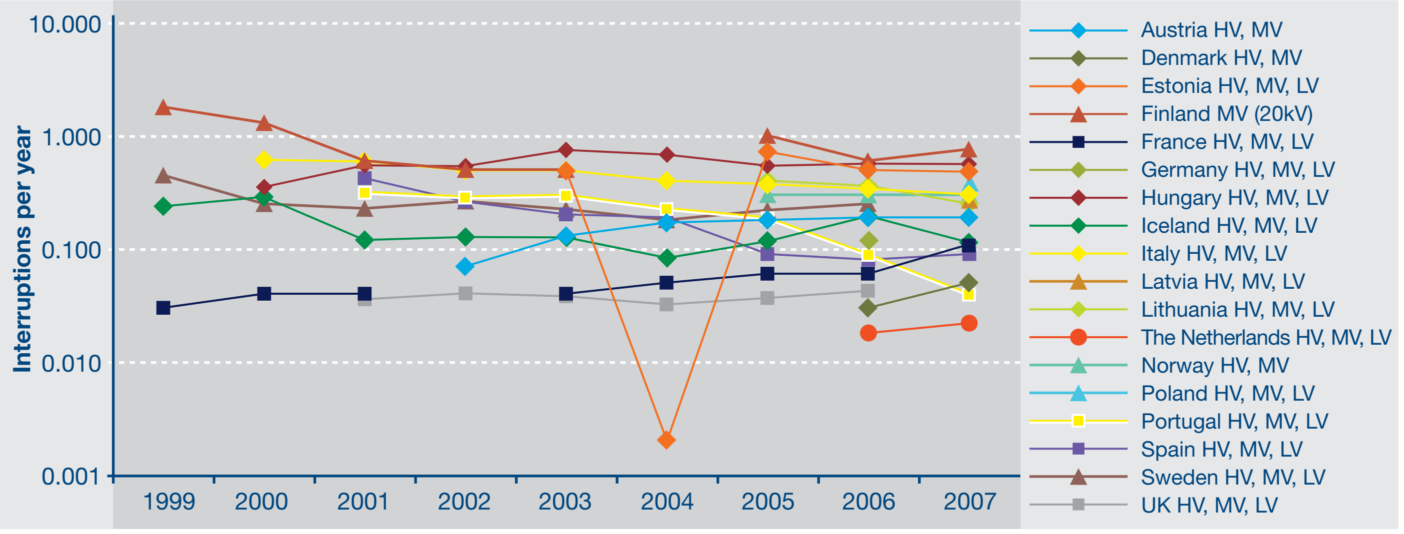


FIGURE COS 2.9 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; MINUTES LOST PER YEAR (1999-2007) - LOGARITHMIC SCALE

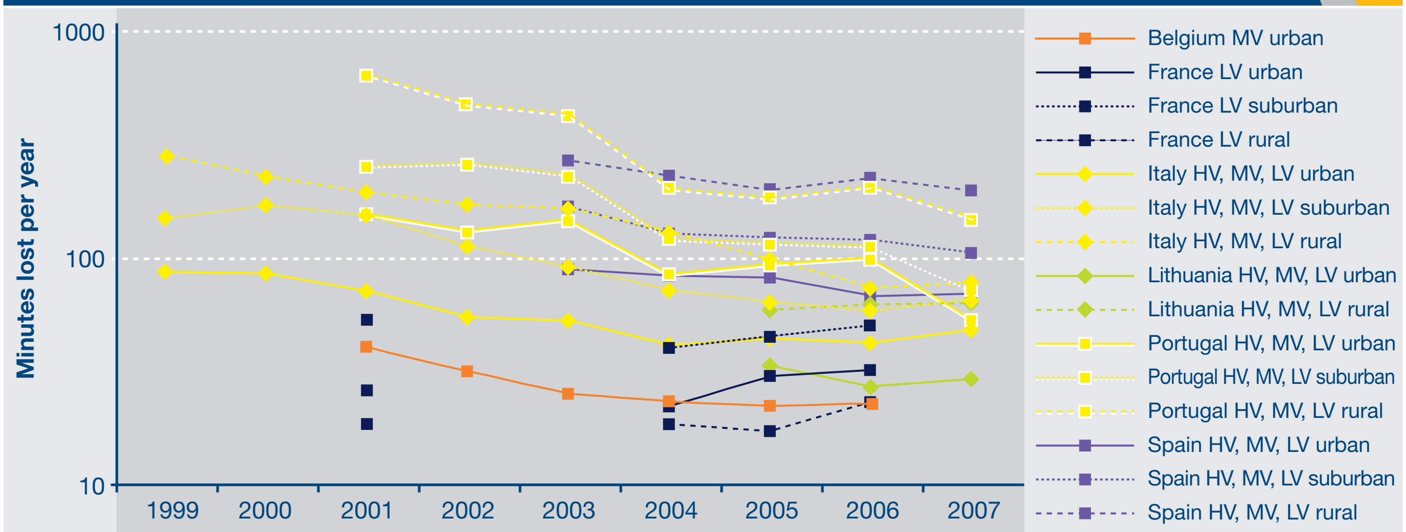


FIGURE COS 2.10 COMPARISON OF UNPLANNED INTERRUPTIONS VALUES BETWEEN DIFFERENT AREAS IN 6 COUNTRIES; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) - LOGARITHMIC SCALE

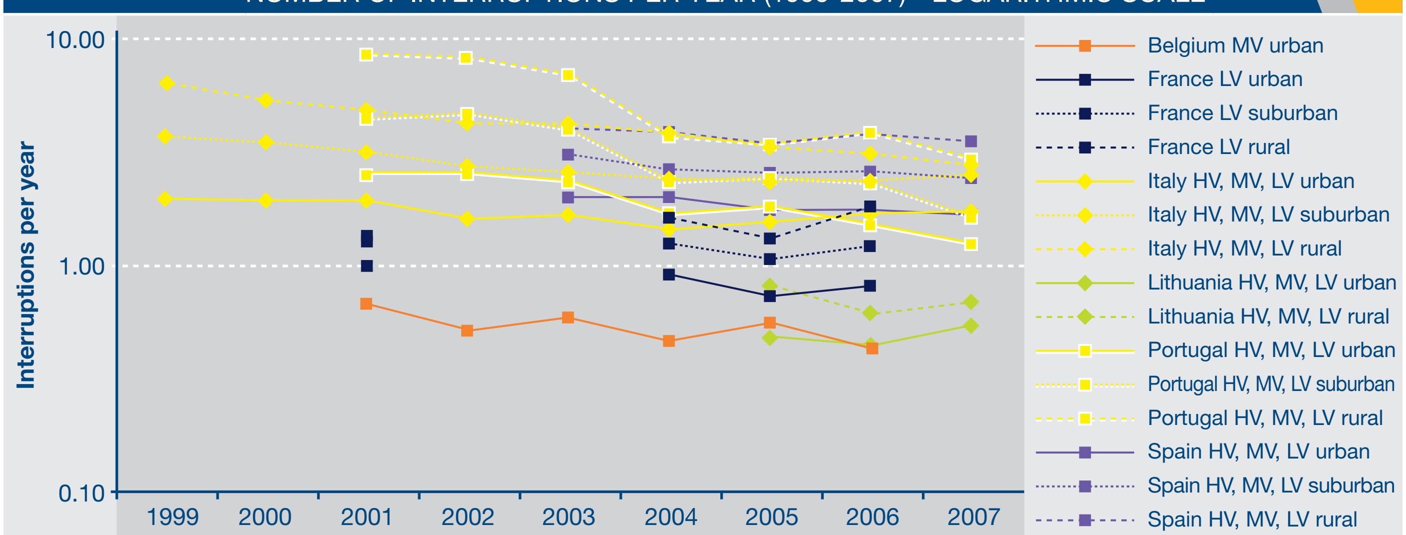


FIGURE COS 2.11A UNPLANNED INTERRUPTIONS PER MEDIUM VOLTAGE LEVEL; MINUTES LOST PER YEAR (1999-2007) ACCORDING TO TABLE 2.11 IN ANNEX 1 ABOVE

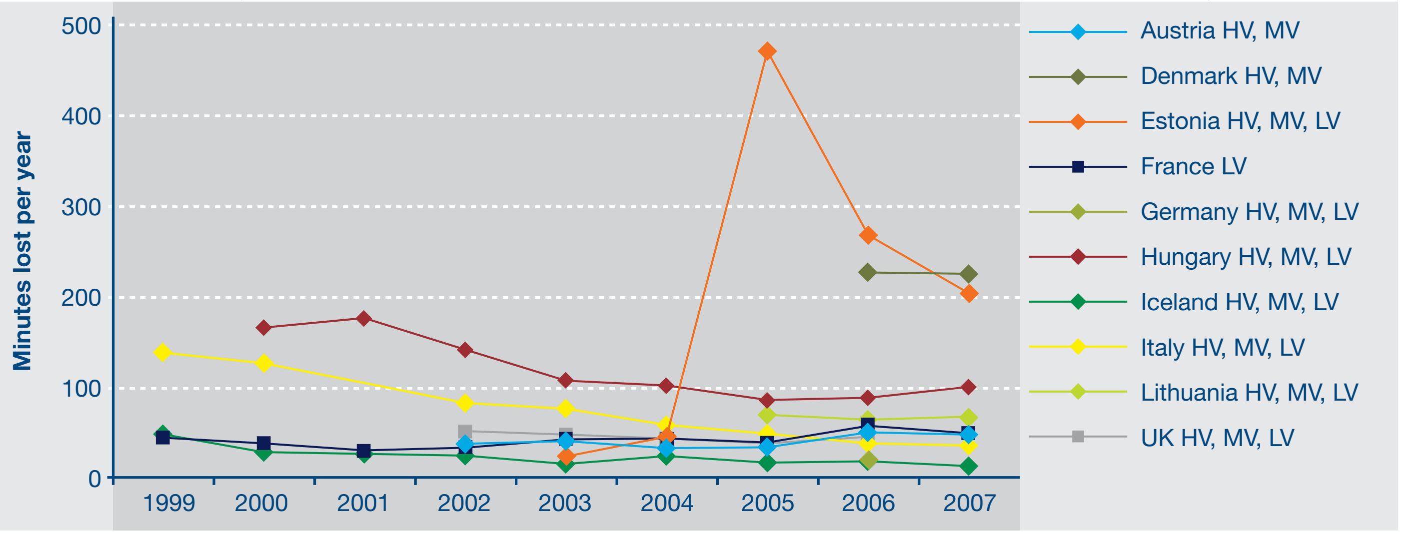


FIGURE COS 2.11B UNPLANNED INTERRUPTIONS PER MEDIUM VOLTAGE LEVEL; MINUTES LOST PER YEAR (1999-2007) ACCORDING TO TABLE 2.11 IN ANNEX 1 ABOVE - LOGARITHMIC SCALE

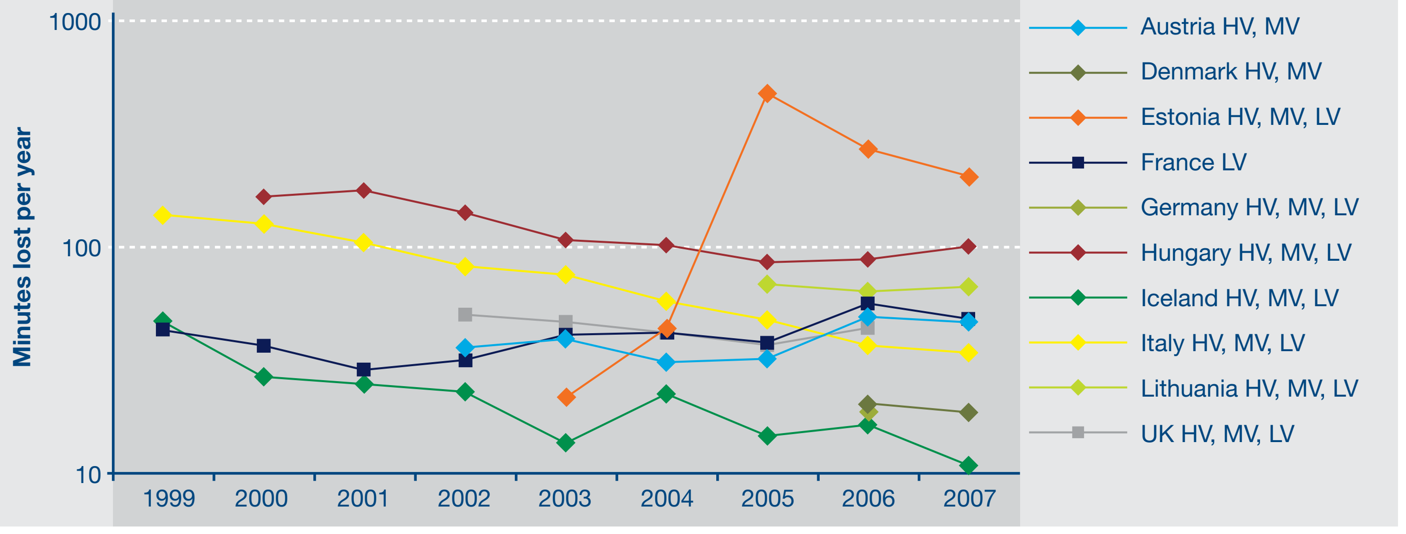


FIGURE COS 2.12A UNPLANNED INTERRUPTIONS PER MEDIUM VOLTAGE LEVEL; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) ACCORDING TO TABLE 2.12 IN ANNEX 1 ABOVE

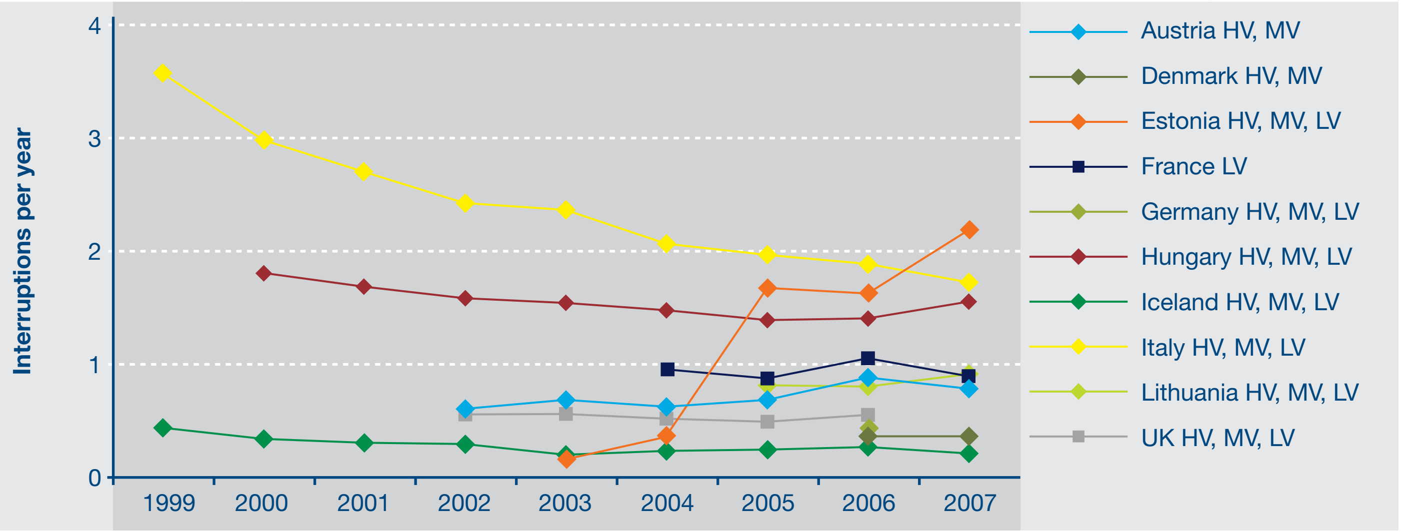


FIGURE COS 2.12B UNPLANNED INTERRUPTIONS PER MEDIUM VOLTAGE LEVEL; NUMBER OF INTERRUPTIONS PER YEAR (1999-2007) ACCORDING TO TABLE 2.12 IN ANNEX 1 ABOVE - LOGARITHMIC SCALE

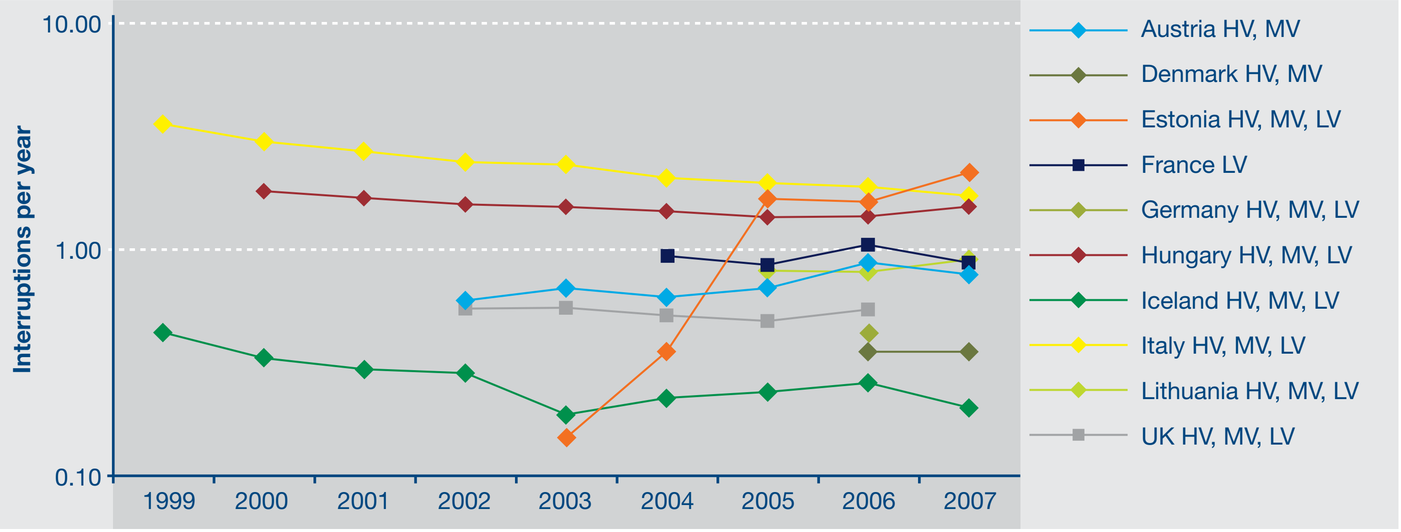
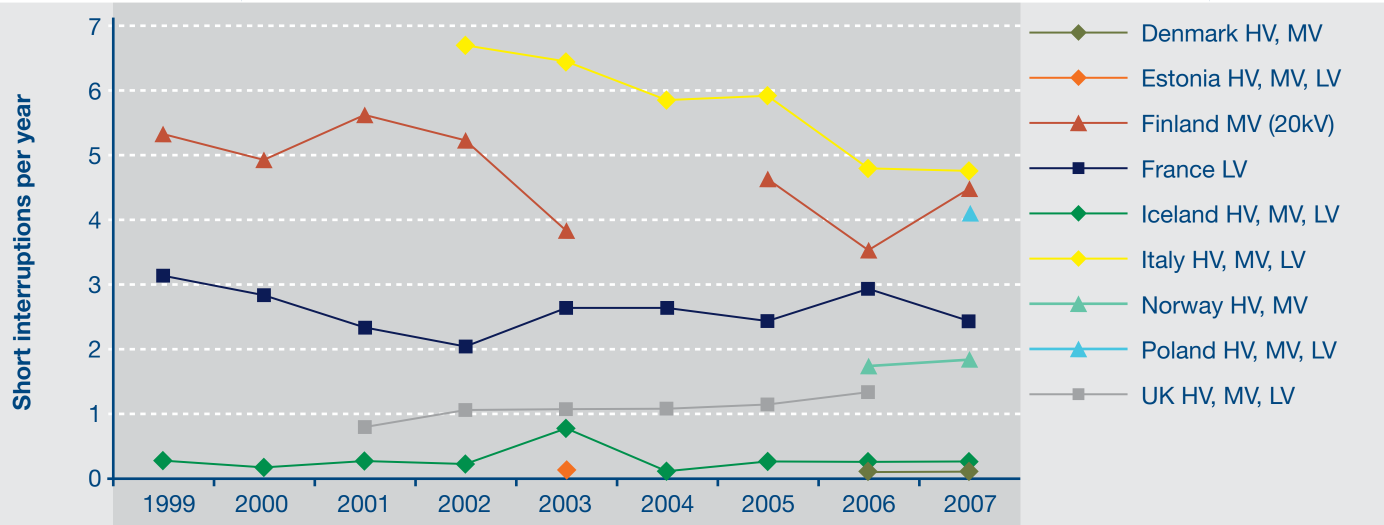


FIGURE COS 2.13A UNPLANNED INTERRUPTIONS;
NUMBER OF SHORT INTERRUPTIONS PER YEAR (1999-2007)



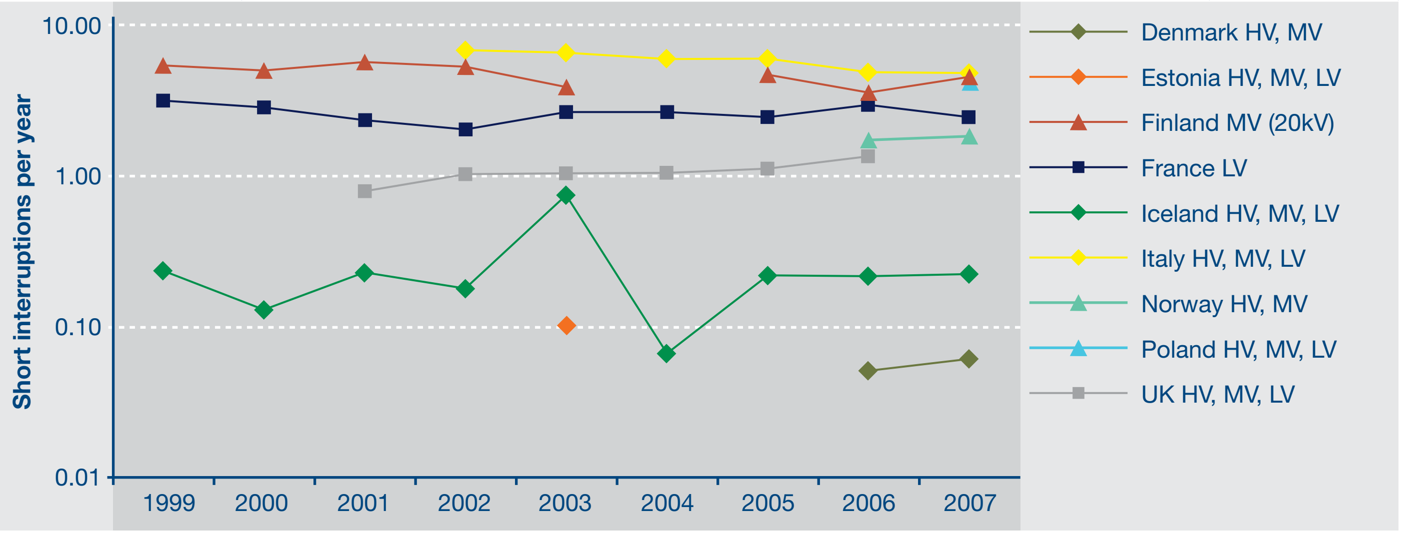
The data on the number of short interruptions is especially hard to compare between different countries due to the fact that different durations and aggregation rules are in use.

In some cases, the same customer is interrupted twice or more with only a few minutes time in between. This may be due to unsuccessful autoreclosing actions or due to manual switching actions during the restoration of the supply. Two or more interruptions within a short time period may be counted as individual interruptions or as one interruption with a duration equal to the sum of the individual durations.

When system indices are considered, the impact of multiple interruptions on the continuity indicators is likely to be small, but for site indices the impact may be big. Counting multiple interruptions as one interruption may result in the maximum duration limit being exceeded, whereas counting them as individual interruptions may result in the maximum number of interruptions being exceeded.

For short interruptions, the way in which multiple interruptions are treated could have a significant influence. For this reason, a comparison is not possible.

FIGURE COS 2.13B UNPLANNED INTERRUPTIONS; NUMBER OF SHORT INTERRUPTIONS PER YEAR (1999-2007) - LOGARITHMIC SCALE



VQ1 Voltage quality regulation

The tables in this Annex have informed the analysis contained in Chapter 3, but do not directly correspond to any other tables or figures in the report.

TABLE VQ 1.1 VOLTAGE QUALITY STANDARDS DIFFERENT FROM EN 50160 APPLIED IN VARIOUS EUROPEAN COUNTRIES

Country	Supply voltage variations	Voltage swells	Voltage dips	Rapid voltage changes	Flicker	Voltage unbalance	Harmonics	Inter-harmonics	Mains signalling voltage
France[1]	**LV:** +10/-10 % (decree) **MV:** U_c=±5 % U_n, U_f=±5 % U_c (contracts) +10/-10 % (decree) **HV: 63, 90kV:** $U_c=U_n$±6 % $U_f=U_c$±8 % **150kV:** $U_c=U_n$±7 % $U_f=U_c$±10 % **225kV:** U_c=200/245 kV U_f=200/245 kV **EHV: 400kV:** U_c=380/420 kV U_f=380/430 kV	EN 50160	Only voltage dips deeper than 30% and longer than 600 ms are taken into account **MV:** customised contractual levels depending on the local conditions on the site (cannot be less than 5 vd/y) **HV and EHV:** customised contractual levels (5vd/y) **D(T)[2]:** customised contractual levels.	EN 50160	**LV, MV, HV and EHV:** Plt ≤ 1 **D(T):** Plt ≤ 1	**LV, MV, HV and EHV:** τvm ≤ 2 % (average square over a period of 10 min) **D(T):** τvm ≤ 2% (average square over a period of 10 min).	**MV:** Rates of harmonic voltages Table VQ1.2. **HV and EHV:** Rates of harmonic voltages Table VQ1.2 **D(T):** Rates of harmonic voltages Table VQ1.2	**LV, MV, HV and EHV:** none	**LV, MV, HV and EHV:** none
United Kingdom[3]	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160

(1) U_c: contractual voltage; U_n: nominal voltage; U_f: supply voltage
(2) D(T): Connection points between distribution and transmission networks
(3) EN 50160 and EN 61000 generally cover voltage quality standards. Specifically, they are implemented by Engineering Recommendations prepared by the network companies:
- ER P28 - planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom (e.g. flicker)
- ER P29 - Planning limits for voltage unbalance in the United Kingdom
- ER G5/4 - Harmonics limits and regulations (BS EN 61000-4-7)

Country	Supply voltage variations	Voltage swells	Voltage dips	Rapid voltage changes	Flicker	Voltage unbalance	Harmonics	Inter-harmonics	Mains signalling voltage
Hungary	**U_n ≤ 1 kV:** U_n ±7.5 % (10 min mean 95 % of the week), U_n ±10 % (10 min mean 100 % of the week), U_n ±15 % (all 1 min mean values).	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160
the Netherlands	**U_n ≤ 1 kV:** Same limits as EN 50160 but without exceptions for remote areas etc. **1 kV < U_c < 35 kV:** U_c ± 10% (10 min mean 95% of the week), U_c +10/-15% (all 10 min mean values). **U_c ≥ 35 kV:** U_c ± 10% (10 min mean 99.9 % of the week).	EN 50160	EN 50160	**All voltage levels:** ≤ 10 % of U_n ≤ 3 % of U_n in a situation without loss of generation, large consumers or connections.	**All voltage levels:** Plt ≤ 1 during 95 % of the values averaged over 10 minutes during an examinations period of 1 week. Plt ≤ 5 for all values averaged over 10 minutes during an examination period of 1 week.	**U_c < 35 kV:** ≤ 2% (10 min mean 95 % of the week) ≤ 3 % (all 10 min mean values) **U_c ≥ 35 kV:** ≤ 1% during 99.5 % of the values averaged over 10 minutes during an examination period of 1 week.	**U_n ≤ 1 kV:** In addition to EN 50160: THD ≤ 12% including the 40th order during 99.9 % of the time. **35 kV ≤ U_c < 110 kV:** THD ≤ 6 % including the 40th order 95 % of the week, 10 min mean values. THD ≤ 7 % including the 40th order 99.9 % of the week, 10 min mean values. **U_c ≥ 110 kV:** THD ≤ 5 % including the 40th order 95 % of 1 week, 10 min mean values. THD ≤ 6 % including the 40th order 99.9 % of 1 week, 10 min mean values.	EN 50160	EN 50160

Country	Supply voltage variations	Voltage swells	Voltage dips	Rapid voltage changes	Flicker	Voltage unbalance	Harmonics	Inter-harmonics	Mains signalling voltage
Norway	**U_n ≤ 1 kV:** U_n ± 10% (all 1 min mean values)	Same as RVC	Same as RVC	**U_c ≤ 35 kV:** $\Delta U_{steadystate}$ ≥ 3% and ΔU_{max} ≥ 5% shall be limited to 24 times per 24 hours. Exception for some causes. **U_c > 35 kV:** the maximum number is 12 per 24 hour	**U_c ≤ 35 kV:** Pst ≤ 1,2 (95% of the week) Plt ≤ 1 (100% of the time) **U_c > 35 kV:** Pst ≤ 1 (95% of the week) Plt ≤0,8 (100% of the time)	**All voltage levels:** ≤ 2% (all 10 min mean values)	**U_c ≤ 35 kV:** THD ≤ 8% (all 10 min mean values) THD ≤ 5% (all week mean values) **35 kV < U_c ≤ 245 kV:** THD ≤ 3% (all 10 min mean values) **U_c > 245 kV:** THD ≤ 2 % (all 10 min mean values) For all voltage levels: Limits for individual harmonics (all orders) apply as 10 min mean values 100% of the time.	The regulator can specify	The regulator can specify
Portugal	**In LV/MV:** EN 50160. **In HV/EHV:** U_c=U_n±7% U_f=U_c±5%(4)	EN 50160	EN 50160	EN 50160	**In LV/MV:** - EN 50160. **In HV/EHV:** Pst<1:	Limits in EN 50160 apply also in HV and EHV networks.	**In LV/MV:** EN 50160 **In HV:** THD ≤ 8% **In EHV:** THD ≤ 4 % Plus limits for all harmonic orders. All limits apply 95% of the week, 10 min mean values	None	None

(4) U_c: contractual voltage; U_n: nominal voltage; U_f: supply voltage
Under normal operating conditions, during each period of 1 week, 95% of the 10 min mean RMS values of the supply voltage shall be within this range.

Country	Supply voltage variations	Voltage swells	Voltage dips	Rapid voltage changes	Flicker	Voltage unbalance	Harmonics	Inter-harmonics	Mains signalling voltage
Spain	U_c ± 7% (10min mean 95 % of the week)	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160	EN 50160

TABLE VQ 1.2 FRANCE: RATES OF HARMONIC VOLTAGES

MV networks					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Rank	Thresholds (%)	Rank	Thresholds (%)	Rank	Thresholds (%)
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.5	15 and 21	0.5	6 to 24	0.5
13	3				
17	2				
19, 23 and 25	1.5				
THD ≤ 8%					

HV networks					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Rank	Thresholds (%)	Rank	Thresholds (%)	Rank	Thresholds (%)
5 and 7	4	3	4	2	3
11 and 13	3	9	2	4	2
17 and 19	2	15 and 21	1	6 to 24	1
23 and 25	1.5				
THD ≤ 6%					

Connection points between distribution and transmission networks					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Rank	Thresholds (%)	Rank	Thresholds (%)	Rank	Thresholds (%)
5 and 7	4	3	4	2	3
11 and 13	3	9	2	4	2
17 and 19	2	15 and 21	1	6 to 24	1
23 and 25	1.5				
THD ≤ 6%					

TABLE VQ 1.3 NORWAY: LIMITS FOR FLICKER SEVERITY: NETWORK COMPANIES SHALL ENSURE THAT FLICKER SEVERITY DOES NOT EXCEED THE FOLLOWING VALUES IN POINTS OF CONNECTION WITH THE RESPECTIVE NOMINAL VOLTAGE VALUE, FOR THE RESPECTIVE TIME INTERVALS:

Flicker severity index	$0.23 \leq U_n \leq 35$ kV	35 kV < U_n	Time interval
Short-term flicker severity, P_{st} [pu]	1.2	1.0	95% of the week
Long-term flicker severity, P_{lt} [pu]	1.0	0.8	100% of the time

TABLE VQ 1.4 NORWAY: LIMITS FOR RAPID VOLTAGE CHANGES: NETWORK COMPANIES SHALL ENSURE THAT RAPID VOLTAGE CHANGES DO NOT EXCEED THE FOLLOWING VALUES IN POINTS OF CONNECTION WITH THE RESPECTIVE NOMINAL VOLTAGE VALUE, FOR THE RESPECTIVE FREQUENCY.

Rapid voltage changes	Maximum number per 24 hour period	
	$0{,}23 \leq U_n \leq 35$ kV	35 kV $< U_n$
$\Delta U_{steadystate} \geq 3$ %	24	12
$\Delta U_{max} \geq 5$ %	24	12

TABLE VQ 1.5 NORWAY: LIMITS FOR INDIVIDUAL HARMONIC VOLTAGES (ALL 10 MIN MEAN VALUES OF THD AND INDIVIDUAL HARMONICS SHALL COMPLY WITH THESE LIMITS)

Nominal voltage from and including 230 V up to and including 35 kV					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5	6.0 %	3	5.0 %	2	2.0 %
7	5.0 %	9	1.5 %	4	1.0 %
11	3.5 %	> 9	0.5 %	> 4	0.5 %
13	3.0 %				
17	2.0 %				
19, 23, 25	1.5 %				
> 25	1.0 %				
THD ≤ 8% all 10 min mean values , THD ≤ 5% all week mean values					

Nominal voltage from 35 kV up to and including 245 kV					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5	3.0 %	3	3.0 %	2	1.5 %
7, 11	2.5 %	9	1.5 %	4	1.0 %
13, 17	2.0 %	15, 21	0.5 %	6	0.5 %
19, 23	1.5 %	> 21	0.3 %	> 6	0.3 %
25	1.0 %				
> 25	0.5 %				
THD ≤ 3 % all 10 min mean values					

Nominal voltage above 245 kV					
Odd harmonics				Even harmonics	
Not multiples of 3		Multiples of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5, 7	2.0 %	3	2.0 %	2	1.0 %
11, 13, 17, 19	1.5 %	9	1.0 %	4, 6	0.5 %
23, 25	1.0 %	15, 21	0.5 %	> 6	0.3 %
> 25	0.5 %	> 21	0.3 %		
THD ≤ 2 % all 10 min mean values					

TABLE VQ 1.6 PORTUGAL: FOR EHV AND HV, UNDER NORMAL CONDITIONS, DURING EACH PERIOD OF 1 WEEK, 95% OF THE 10 MIN MEAN RMS VALUES OF EACH INDIVIDUAL HARMONIC VOLTAGE SHALL BE LESS THAN OR EQUAL TO THE FOLLOWING VALUES

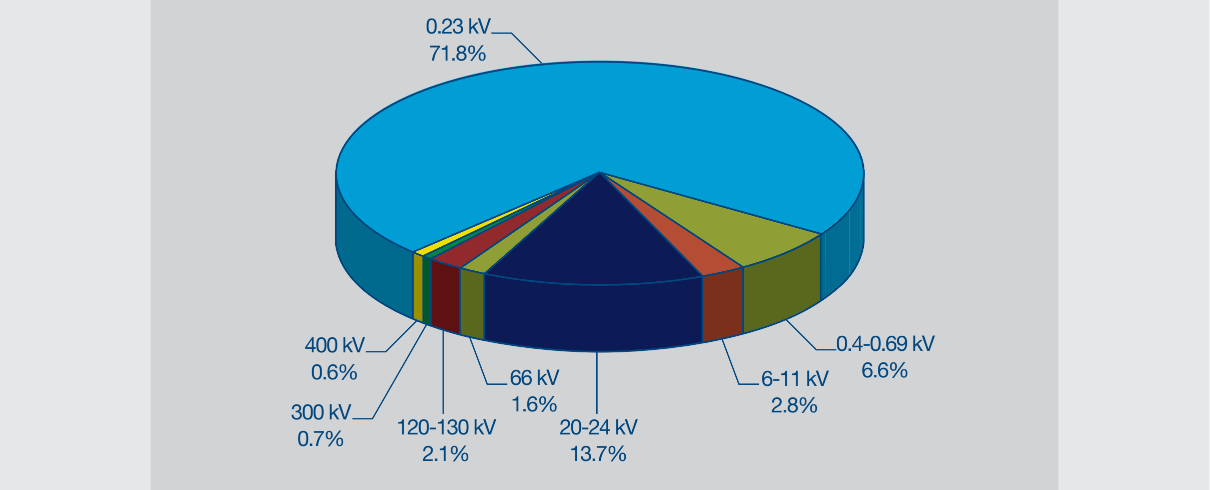
Odd harmonics						Even harmonics		
Not multiples of 3			Multiples of 3					
h	U_h (%)		h	U_h (%)		h	U_h (%)	
	HV	EHV		HV	EHV		HV	EHV
5	4.5	3.0	3	3.0	2.0	2	1.6	1.5
7	3.0	2.0	9	1.1	1.0	4	1.0	1.0
11	2.5	1.5	15	0.3	0.3	6	0.5	0.5
13	2.0	1.5	21	0.2	0.2	8	0.4	0.4
17	1.3	1.0	>21	0.2	0.2	10	0.4	0.4
19	1.1	1.0				12	0.2	0.2
23	1.0	0.7				>12	0.2	0.2
25	1.0	0.7						
>25	0.2+12.5/h	0.2+25/h						
$THD_{HV} \leq 8\%$; $THD_{EHV} \leq 4\%$								

VQ2 Voltage quality data

Norway: Actual voltage quality data recorded by network companies in the period from 1993 to 2003

In the period from 1993 to 2003, network companies reported on a voluntary basis the actual voltage quality data to SINTEF Energy Research (Norwegian national research institute), who structured the data and published statistics, the last one in 2003, as part of a national R&D project. This voluntary campaign included both continuous monitoring and random measurements, including even trouble shooting (customer complaints). In December 2003, the VQ database at SINTEF Energy Research contained measurement results from a total of 671 measuring points (NOTE: not all continuously monitored during the period). 39 out of 482 LV measurement sites are due to voltage quality complaints. Figure VQ2.1 shows how the measuring points were allocated on different voltage levels. The measurement results were published in 2004[36]:

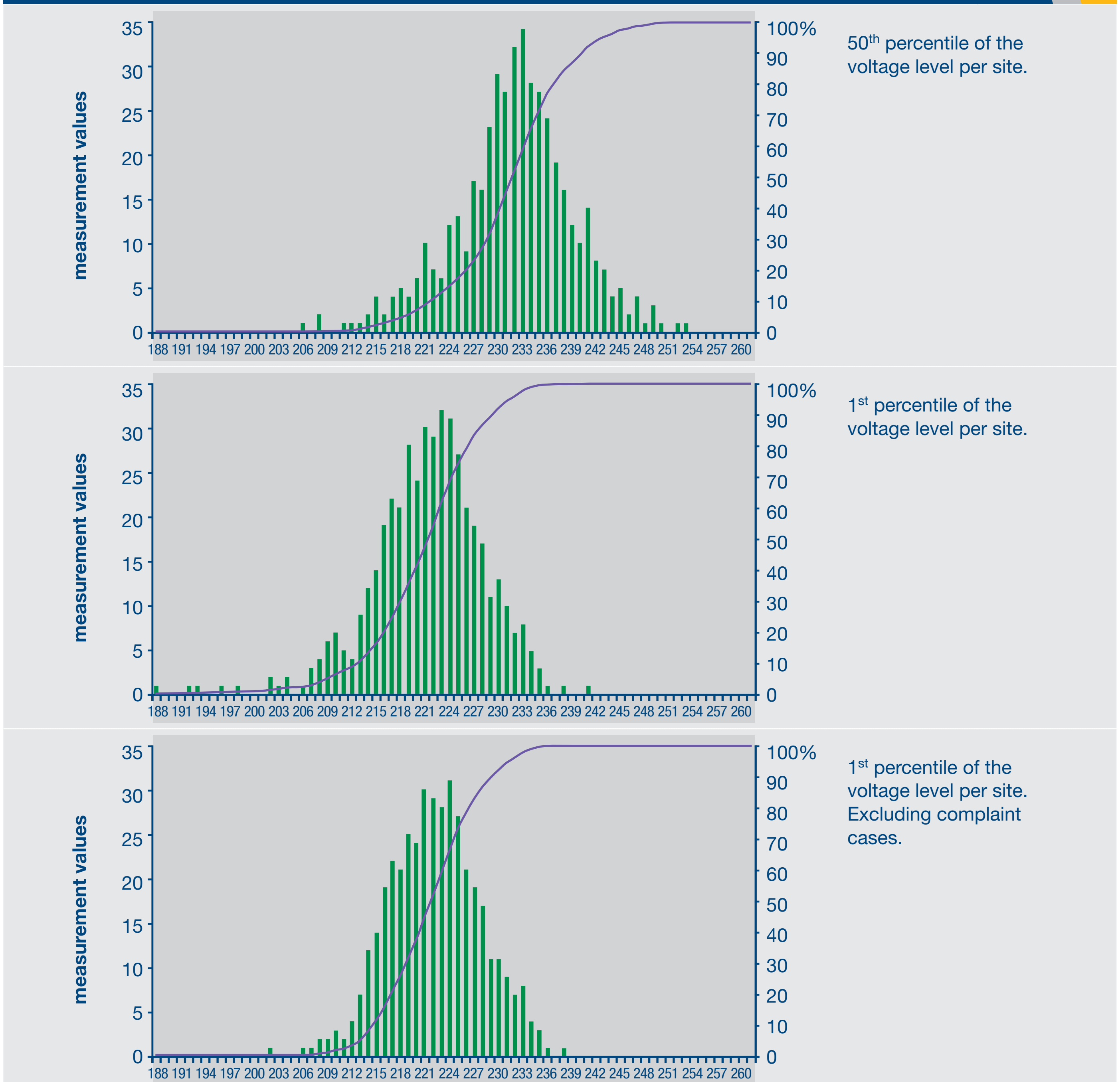
FIGURE VQ 2.1 NORWAY: MEASURING POINTS ALLOCATED ON DIFFERENT VOLTAGE LEVELS IN THE PERIOD 1993-2003

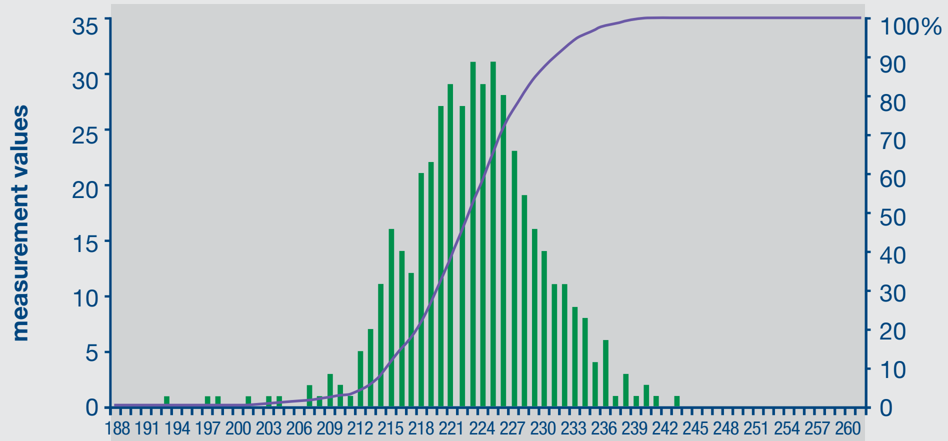


In the following figures, an excerpt is provided of the main results collected by the voltage quality monitoring campaign.

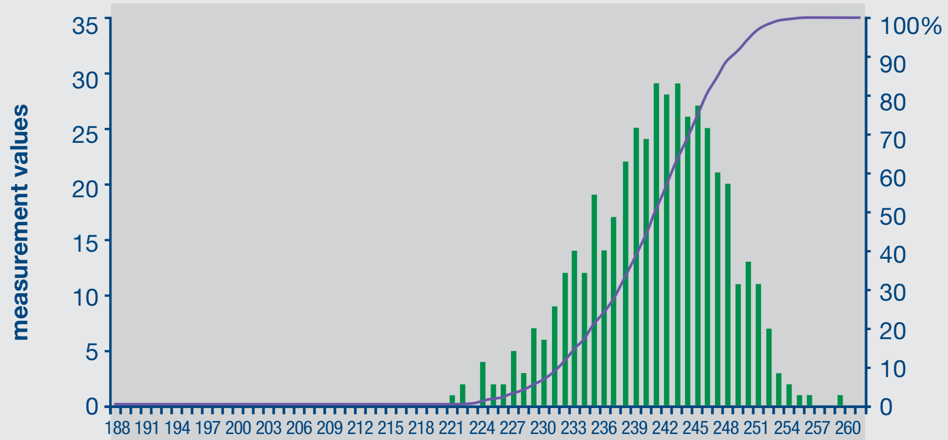
36 EBL-K 161-2004/SINTEF TR A5883, Spenningskvalitet og kortvarige avbrudd i Norge. Rikets tilstand 1993-2003, H. Seljeseth, EBL Kompetanse, 2004. Only in Norwegian. Results are published with the permission of EBL Kompetanse AS (www.ebl.no).

FIGURE VQ 2.2 NORWAY: SLOW SUPPLY VOLTAGE VARIATIONS IN LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003. THE FIGURES SHOW IN THE Y AXIS HOW MANY SITES THE PERCENTILE VOLTAGE INDICATED IN THE X AXIS HAVE BEEN MEASURED (MEASUREMENT TIME PER SITE: FROM 6 MONTHS TO 10 YEARS)

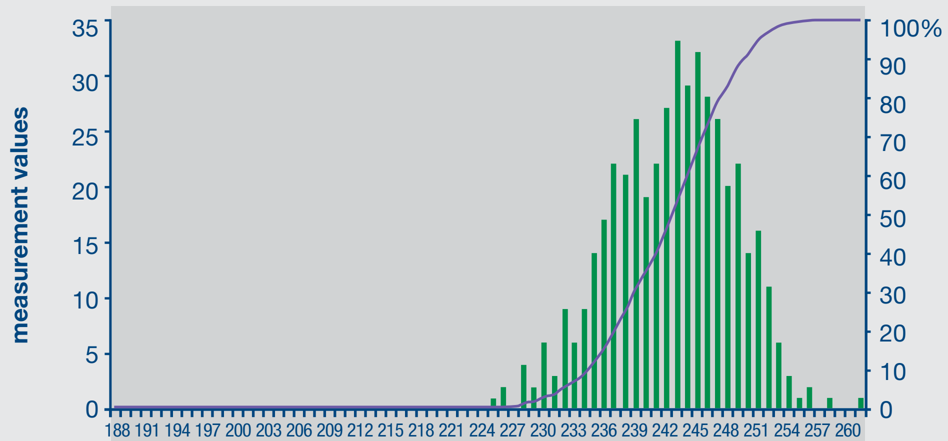




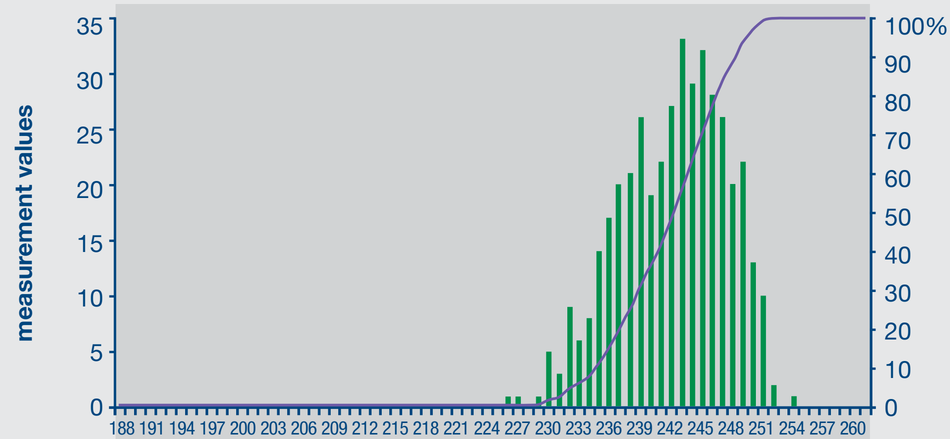
5th percentile of the voltage level per site.



95th percentile of the voltage level per site.



99th percentile of the voltage level per site.



99th percentile of the voltage level per site. Excluding complaint cases.

TABLE VQ 2.1 NORWAY: AVERAGE NUMBER OF VOLTAGE SWELLS IN THE LOW VOLTAGE NETWORK PER YEAR IN THE PERIOD FROM 1993 TO 2003 WITH REFERENCE TO MEASURING SITES

Voltage u	Duration t (ms)					
(%)	20 < t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000
110 < u ≤ 115	3	2	1	0	0	0
115 < u ≤ 120	1	0	0	0	0	0
120 < u	1	0	0	0	0	0

Measurement time per site: from 6 months to 10 years

TABLE VQ 2.2 NORWAY: VOLTAGE UNBALANCE IN THE LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003. THE PERCENTILES INDICATED ARE THE AVERAGE OF THE CORRESPONDING PERCENTILES MEASURED ON ALL MEASURING SITES

Voltage unbalance				
1st Percentile	5th Percentile	50th Percentile	95th Percentile	99th Percentile
0.1	0.15	0.4	0.9	1.8

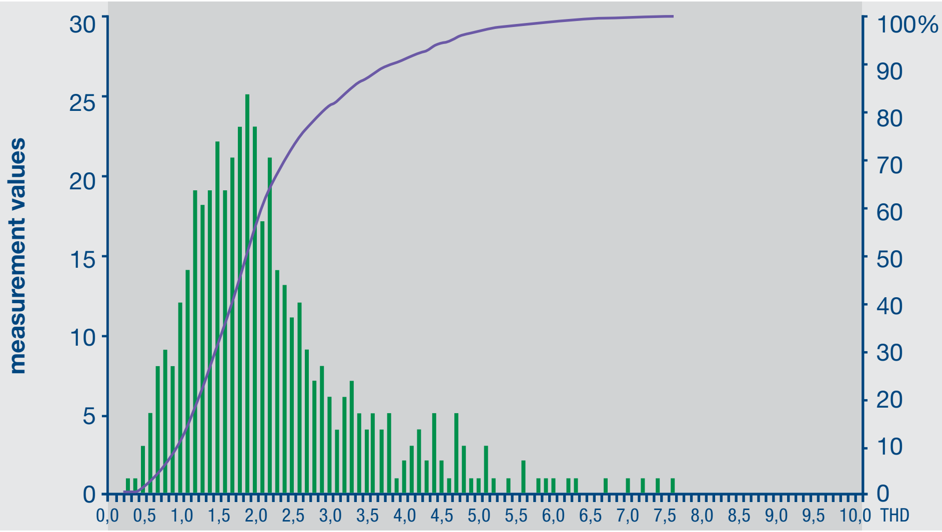
Measurement time per site: from 6 months to 10 years

TABLE VQ 2.3 NORWAY: FLICKER SEVERITY IN THE LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003. THE PERCENTILES INDICATED ARE THE AVERAGE OF THE CORRESPONDING PERCENTILES MEASURED ON ALL MEASURING SITES

	Flicker		
	5th Percentile	50th Percentile	95th Percentile
Pst	0.11	0.39	0.58
Plt	0.10	0.35	0.51

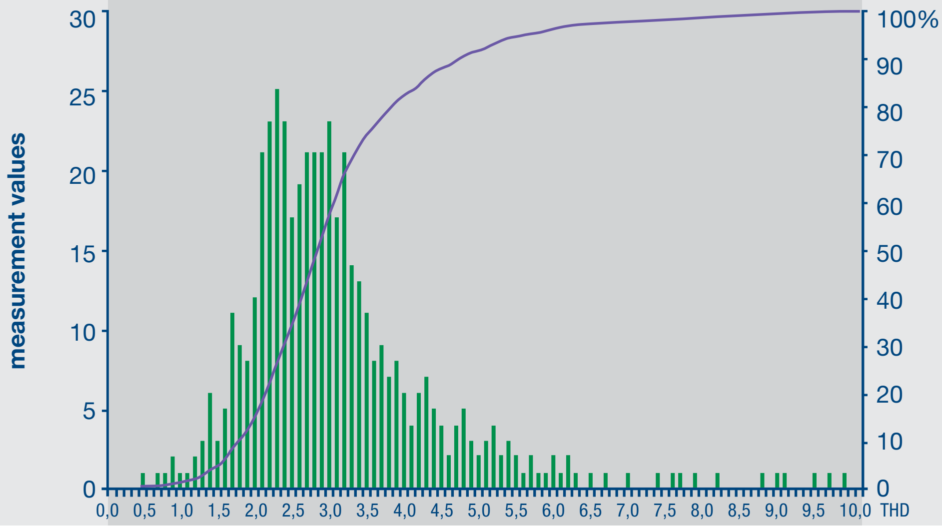
Measurement time per site: from 6 months to 10 years

FIGURE VQ 2.3 NORWAY: HARMONIC VOLTAGES IN THE LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003. THE FIGURES SHOW IN THE Y AXIS HOW MANY SITES THE 50TH PERCENTILE OF THD INDICATED IN THE X AXIS HAS BEEN MEASURED



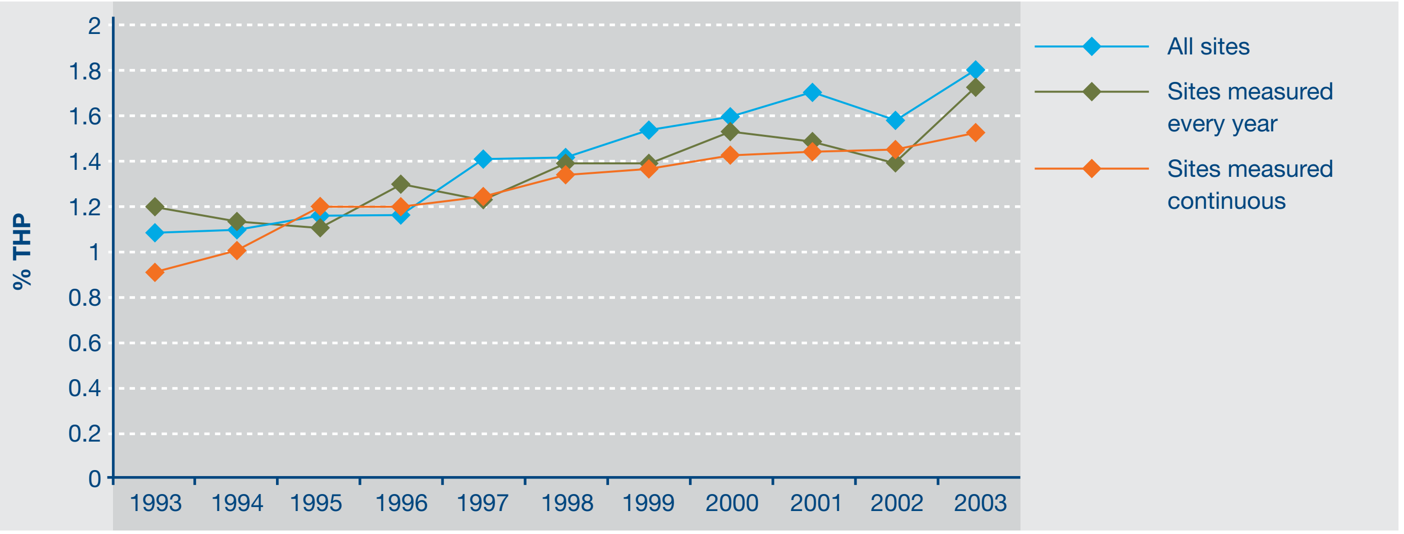
Measurement time per site is from 6 months to 10 years

FIGURE VQ 2.4 NORWAY: HARMONIC VOLTAGES IN THE LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003.). THE FIGURES SHOW IN THE Y AXIS HOW MANY THE 99TH PERCENTILE OF THD INDICATED IN THE X AXIS HAVE BEEN MEASURED



Measurement time per site is from 6 months to 10 years

FIGURE VQ 2.5 NORWAY: HARMONIC VOLTAGES IN THE LOW VOLTAGE NETWORK IN THE PERIOD FROM 1993 TO 2003. DEVELOPMENT OF THE AVERAGE OF THE 50TH PERCENTILE OF THE THD MEASURED IN EACH LV SITE



Measurement time per site is from 6 months to 10 years

Italy: Data related to EHV and HV networks monitoring system recorded in 2007

FIGURE VQ 2.6 ITALY: RESIDUAL VOLTAGE AND DURATION OF ALL DIPS RECORDED IN 380 KV NETWORK IN 2007

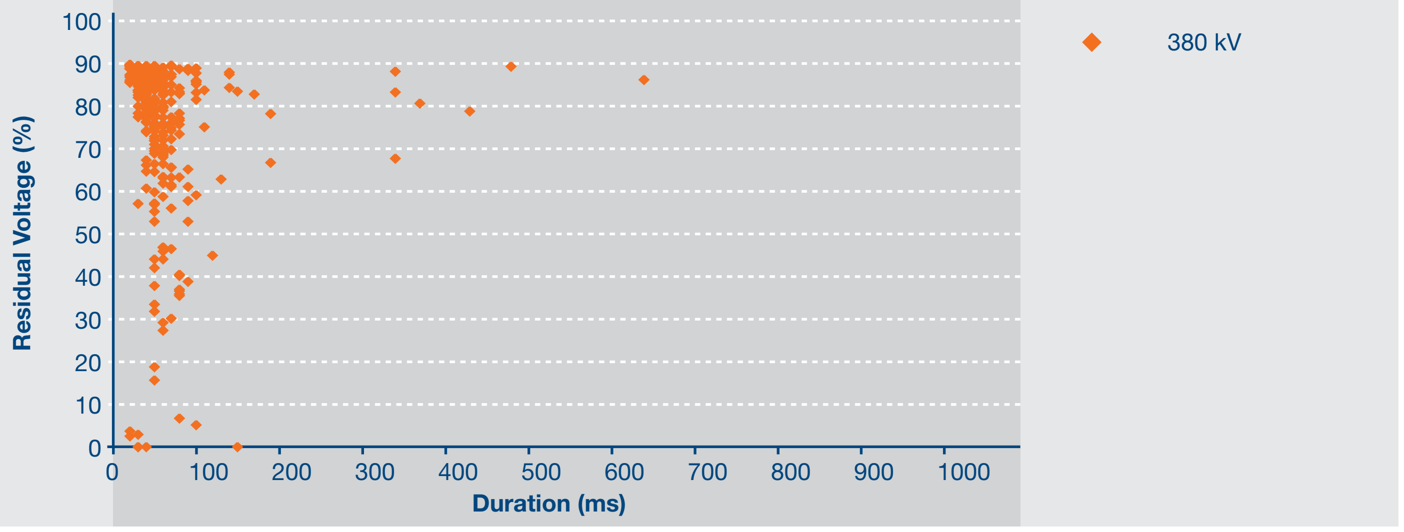


FIGURE VQ 2.7 ITALY: RESIDUAL VOLTAGE AND DURATION OF ALL DIPS RECORDED IN 220 KV NETWORK IN 2007

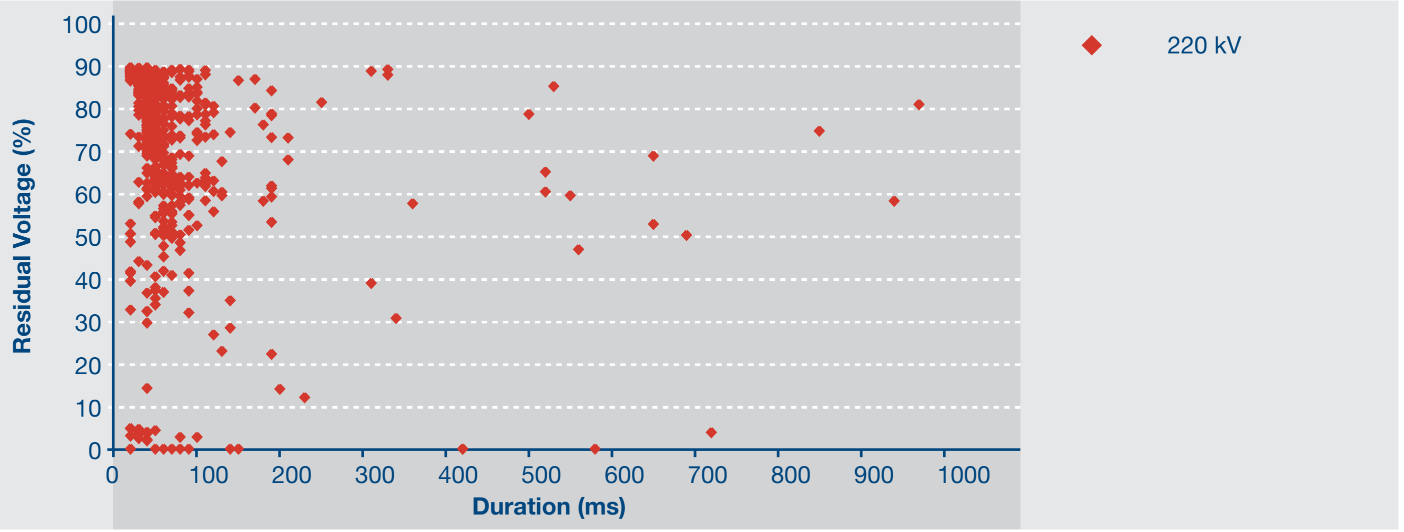
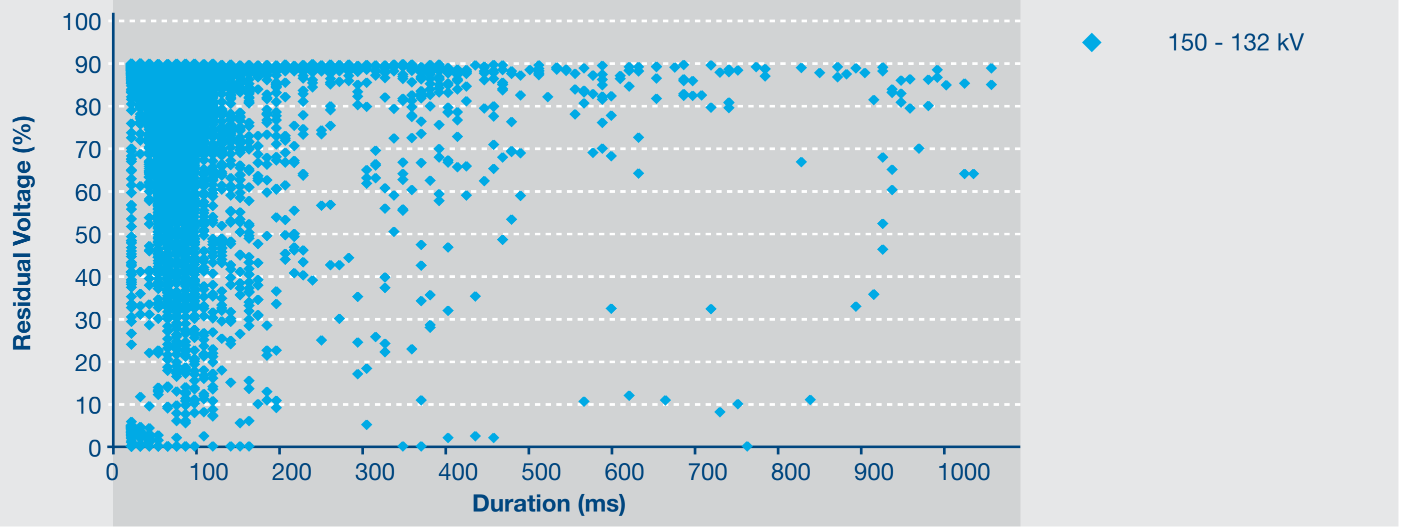


FIGURE VQ 2.8 ITALY: RESIDUAL VOLTAGE AND DURATION OF ALL DIPS RECORDED IN 150 KV AND 132 KV NETWORKS IN 2007



Data related to MV bus-bars in HV/MV substations recorded in 2007

Data reported in the following table:

- refers to the period 01/01/2007 - 30/12/2007 (52 continuous weeks);
- refers to the entire Italian territory, to all types of networks (cable, aerial, mixed), to both types of neutral operation (isolated, grounded through impedance), and includes different distribution networks for extension, nominal voltage level, installed power of HV/MV transformers;
- is compliant with EN 50160 and EN 61000-4-30;
- refers to a total number of aggregated monitoring points, which is 404;
- refers to a total number of the equivalent monitoring points (due to more than one reason, for some monitoring points, VQ data in some weeks is not available) in the considered period (01/01/2007-30/12/2007), which is 369.9.

TABLE VQ 2.4 ITALY: UNBALANCE RELATED TO MV BUS-BARS IN HV/MV SUBSTATIONS.		
	Voltage unbalance	
	Number of monitoring points	
	With unbalance between 1% and 2% for more than 5% of the time	With unbalance higher than 2% for more than 5% of the time
For at least 1 week	5	4
For at least 2 weeks	5	3
For at least 3 weeks	2	2
For at least 4 weeks	2	2

Italy, data related to MV PCCs along the MV lines (not a statistically representative sample) recorded in 2007

The following data:

- refers to the period 01/01/2007 - 30/12/2007 (52 continuous weeks);
- refers to the entire Italian territory, to all type of networks (cable, aerial, mixed), to both type of neuter operation (isolated, grounded through impedance), to all network extensions, to all voltage levels, to all powers of HV MV transformers;
- is compliant with EN 50160 and EN 61000-4-30;
- refers to a total number of aggregated monitoring points, which is 189;
- refers to a total number of the equivalent monitoring points (due to more than one reason, for some monitoring points VQ data in some weeks is not available) in the considered period (01/01/2007-30/12/2007), which is 159.3.

TABLE VQ 2.5 ITALY: VOLTAGE VARIATIONS RELATED TO MV PCCs ALONG THE MV LINES			
	Voltage variations		
	Number of monitoring points		
	With V exceeding ±10% for more than 5% of the time	With V exceeding ±7.5% for more than 5% of the time	With V exceeding ±5% for more than 5% of the time
For at least 1 week	0	11	66
For at least 2 weeks	0	4	43
For at least 3 weeks	0	2	40
For at least 4 weeks	0	2	38

TABLE VQ 2.6 ITALY: VOLTAGE UNBALANCE RELATED TO MV PCCs ALONG THE MV LINES		
	Voltage unbalance	
	Number of monitoring points	
	With unbalance between 1% and 2% for more than 5% of the time	With unbalance higher than 2% for more than 5% of the time
For at least 1 week	4	3
For at least 2 weeks	3	2
For at least 3 weeks	3	2
For at least 4 weeks	2	2

Annex 3: Annex to Chapter 4 on Commercial Quality

The tables in this Annex have informed the analysis contained in Chapter 4, but do not directly correspond to any other tables or figures in the report.

TABLE CQ 1.1 TIME FOR RESPONSE TO CLAIM OF CUSTOMERS FOR NETWORK CONNECTION

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			exact wording: 10 working days general terms and conditions
Belgium-Walloon	OS	10	day	N/A		N/A			
Cyprus	GS	20	day	99,8	%		17.09	After claim within 10 days	working days
Czech Republic	GS	30/60	day	N/A		Compensation in case of non-performance	20/40/400*	upon request	60 days in case of necessity of metering
Estonia	OS	30	day	14					
Hungary	GS	8	day			Compensation	20	upon claim	Household consumers
Latvia	OS	15	day						
Lithuania	OAR	30	day	15	day				
Luxembourg	OAR	10/30	day	not yet available					no regulatory penalties, legal obligation; 10 days for residential, 30 days for all other customers
Norway	OAR								Within reasonable time
Romania	OS	30	day						if the documentation is complete
Slovenia	GS	10	day	N/A		Compensation	20	upon claim	Regulator's proposal, not yet applied
Spain	GS	15	day			Compensation	Max (€ 30, 10% of first full bill)	Per breach	

* € 20 max. € 2,000 by LV, € 40 max. € 4,000 by MV, € 400 max. € 20,000 by HV

TABLE CQ 1.2 TIME FOR COST ESTIMATION FOR SIMPLE WORKS

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			exact wording: 10 working days general terms and conditions
Belgium-Flemish	OAR	10	day						
Belgium-Walloon	OS	10	day	N/A		N/A			
Cyprus	GS	30	day	94.5	%		34.17	After claim within 10 days	working days
Estonia	OS	30	day						
Hungary	GS	8	day			Compensation	20	upon claim	Household consumers
Italy	GS	20	day	13.71	day	Compensation	€ 30 LV domestic € 60 LV non dom.	Automatic	working days
Norway	OAR								Within reasonable time
Portugal	OS	20 WD, 95%	%	99.9	%				WD - working day
Slovenia	GS	10	day	N/A		Compensation	20	upon claim	Regulator's proposal, not yet applied
Spain	GS	5-60	day			Compensation	Max(€ 30, 10% of first full bill)	Per breach	LV: a) supplies <15 kW: within 5 days b) Other without Substation investment: within 10 days *
United Kingdom	GS	90	day						As well as the guaranteed standard (which only applies to LV service connections) there is a**

* LV: a) supplies <15 kW: within 5 days b) Other without Substation investment: within 10 days c) Other supplies with Substation investment: within a range of 20 to 30 days. MVHV: (new supplies): a) 1-66kV: within 40 days b) >66kV: within 60 days.

** As well as the guaranteed standard (which only applies to LV service connections) there is a requirement in the licence for the DSO to offer terms for connection (i.e. a quote) within 3 months. This is set out in SLC 4D 6(b).

TABLE CQ 1.3 TIME FOR CONNECTING NEW LV CUSTOMERS TO THE NETWORK

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			exact wording: 10 working days general terms and conditions
Belgium-Flemish	OAR	15	day						
Belgium-Walloon	OS	30	day	N/A		N/A			
Cyprus	GS	6	day	92.2	%		17.09	Direct debit	working days
Germany	-	-		0.8	day	No, unless bilateral agreements			value includes only the period between the time from beginning the work on the connection itself*
Italy	GS	15	day	8.96	day	Compensation	€ 30 LV domestic € 60 LV non dom.	Automatic	only simple work; working days
Lithuania	OAR	15	day	11	day				only in case of ordinary connection
Luxembourg	OAR	30	day	not yet available					no regulatory penalties, legal obligation
Norway	OAR								Within reasonable time
Portugal	OS	20 WD, 95%	%	98.5	%				
Slovenia	GS	8	day	N/A					Regulator's proposal, not yet applied
Spain	GS	from 6 to 80	day			Compensation	Max(€ 30, 10% of first full bill)	Per breach	

* Value includes only the period between the time from beginning work on the connection itself (e.g. laying of cable) - but excluding civil engineering works - and the completion/initial operation

TABLE CQ 1.4 TIME BETWEEN SIGNING CONTRACT AND THE START OF SUPPLY

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			exact wording: 10 working days general terms and conditions
Belgium-Walloon	OS	3	day	N/A		N/A			
Germany	OAR			5	day	No, unless bilateral agreements			Due to a business process which is provided by the regulator, the DSO has about 5 working days *
Hungary	GS	8	day			Compensation	20	upon claim	Household consumers
Italy	GS	5	day	1.56	day	Compensation	€ 30 LV domestic € 60 LV non dom.	Automatic	working days
Latvia	OAR	10	day						
Norway	OAR								Within reasonable time
Portugal	OS	2 WD, 90%	%	98.9	%				
Slovenia	GS	8	day	N/A					Regulator's proposal, not yet applied
Spain	GS	5 working days				Compensation	Max(€ 30, 10% of first full bill)	Per breach	following contract signature

* Due to a business process which is provided by the regulator, the DSO has about 5 working days between the effectiveness of connection contract and the start of supply. This is a standard which needs to be met by the DSO. If it is not met, legal consequences can follow but there are no compensation payments to the customer. Data accounts for 2006 and also for 2007.

TABLE CQ 1.5 RESPONSE TIME TO CUSTOMER QUERIES IN WRITTEN FORM

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Cyprus	GS	20	day	99.8	%		17.09	After claim within 10 days	working days
Hungary	GS	15	day			Compensation	20	upon claim	Household consumers
Italy	OS	20	day	54.7	%				90% LV 95% MV within 20 working days
Latvia	OAR	15	day						
Lithuania	OAR	30	day						
Norway	OAR								Data on VQ and CoS: Within one month. In general: Within reasonable time
Portugal	OS	15 WD, 90%	%	97.4	%				
Romania	OS	30	day						
Slovenia	OAR	10	day	N/A					Decree on general conditions for the supply and consumption of electricity
Spain	GS	5-15	day			Compensation	Max(€ 30, 10% of first full bill)	Per breach	Customers: < 15 kW: within 5 working days Rest: within 15 working days

TABLE CQ 1.6 RULES ON ANSWERING CLIENT LETTERS - TIME OF GIVING RESPONSE TO COMPLAINTS

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Belgium-Flemish	OAR	10	day						
Cyprus	GS	20	day	99.8	%		17.09	After claim within 10 days	working days
Czech Republic	GS	15/30	day	N/A		Compensation in case of non-performance	20 each day over limit, max. 800	upon request	30 days in case of necessity of appointments with consumers in order to verify state*
Hungary	GS	15	day			Compensation	20	upon claim	Household consumers
Italy	OS	20	day	54.7	%				90% LV 95% MV within 20 working days
Latvia	OAR	15	day						
Lithuania	OAR	30	day						
Norway	OAR								In general: Within reasonable time; VQ and CoS: First answer within one month, and within four months**
Portugal	GS	15 WD				Compensation	18/30/92 ***	Automatic in the bill	WD - working day; total annual compensations - € 192
Slovenia	OAR	10	day	N/A					Decree on general conditions for the supply and consumption of electricity
Spain	GS	5-15	day			Compensation	Max(€ 30, 10% of first full bill)	Per breach	Customers: < 15 kW: within 5 working days Rest: within 15 working days
United Kingdom	OAR								As of 1 July 2008, DSOs will be subject to complaint handling standards ****

* 30 days in case of necessity of appointments with consumers in order to verify state of delivery point, or inspection of meter

** In general: Within reasonable time; VQ and CoS: First answer within one month, and within four months the network company shall have detected who is responsible for rectifying the problem.

*** € 18 for LV - P<41,4 kVA; € 30 for other LV; € 92 for other voltage levels

**** As of 1 July 2008, DSOs will be subject to complaint handling standards under the provisions of the new Consumer, Estate Agents and Redress Act (2007). The standards will not prescribe timescales for responding to complaints but will require DSOs to put in place appropriate complaint handling procedures. This new requirement builds on the existing licence requirements for complaint handling set out in SLC 21.

TABLE CQ 1.7 RESPONSE TIME TO CUSTOMER COMPLAINTS IN WRITTEN FORM

	Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
		OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
SP	Czech Republic	GS	15/30	day			Compensation in case of non-performance	20 each day over limit, max. 800	upon request	
SP	Hungary	GS	15	day			Compensation	20	upon claim	
SP	Italy	OS	20	day	15.96	day				90% LV 95% MV within 20 working days
SP	Latvia	OAR	15	day						
SP	Lithuania	OAR	30	day	15	day				
SP	Romania	OS	30	day						
USP	Czech Republic	GS	15/30	day			Compensation in case of non-performance	20 each day over limit, max. 800	upon request	
USP	Estonia	OS	15/30	day	15	day		0		business 30, residental 15
USP	Hungary	GS	15	day			Compensation	20	upon claim	
USP	Italy	OS	20	day	15.96	day				90% LV 95% MV within 20 working days
USP	Latvia	OAR	15	day						
USP	Lithuania	OAR								
USP	Portugal	GS	15 WD				Compensation	18/30/92 *	Automatic in the bill	WD - working day; total annual compensations - € 192
USP	Romania	OS	30	day						

* € 18 for LV - P<41,4 kVA; € 30 for other LV; € 92 for other voltage levels

TABLE CQ 1.8 RESPONSE TIME, QUERIES ON COSTS AND PAYMENTS

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			exact wording: 10 working days general terms and conditions
Cyprus	GS	20	day	99.8	%		17.09	After claim within 10 days	working days
Hungary	GS	15	day			Compensation	20	upon claim	Household consumers
Latvia	OAR	5	day						
Lithuania	OAR	10-20	day						10 days for household customers, 20 days for all other customers
Norway	OAR								Within reasonable time
Slovenia	OS	10	day	N/A					Regulator's proposal, not yet applied
Spain	GS	5-15	day			Compensation	Max(€ 30, 10% of first full bill)	Per breach	Customers: < 15 kW: within 5 working days Rest: within 15 working days
Romania	OS	30	day						
United Kingdom	GS	2	day	0.03	%		25		

TABLE CQ 1.9 PUNCTUALITY OF APPOINTMENTS WITH CUSTOMERS

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Cyprus	GS	2	day				34.17	Direct debit	working days - there were no scheduling appointments in 2007
Czech Republic	GS	-		N/A		Compensation in case of non-performance	80	upon request	standard is performed if the appointment is at the proposed date
Hungary	GS	4	hour			Compensation	min. 20	upon claim	minimum € 20 plus travel costs of the DSO
Italy	GS	3	hour			Compensation	€ 30 LV domestic € 60 LV non dom.	Automatic	Applicable under restrictions until 2008
Portugal	GS	2.5	hour			Compensation	18/30/92 *	Automatic in the bill	Total annual compensations - € 1,398
Slovenia	GS	3	hour	N/A					Regulator's proposal, not yet applied
United Kingdom	GS						25		Companies must offer and keep a timed appointment, or offer and keep a timed appointment where requested

* € 18 for LV - P<41,4 kVA; € 30 for other LV; € 92 for other voltage levels

** Companies must offer and keep a timed appointment, or offer and keep a timed appointment where requested by the customer, otherwise a £ 20 payment must be made.

TABLE CQ 1.10 TIME OF GIVING INFORMATION ON A PLANNED INTERRUPTION

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	48	hour			No, unless bilateral agreements			general terms and conditions
Belgium-Walloon	OS	10 - 2	day	N/A		N/A			MV - LV
Cyprus	GS	20	day	99.8	%		17.09	After claim within 10 days	working days
Czech Republic	GS	-		N/A		Compensation in case of non-performance	10% from annual payments*	upon request	standard is performed if the planned outage occurs and terminates exactly at the announced date and time
Estonia	OS	2	day						
Hungary	GS	15	day			Compensation	20	upon claim	Household consumers
Italy	OAR	24	hour						changed from 2008: 48 days excluding an emergency for which a requirement of 24 hours applies
Latvia	OAR	5	day						
Lithuania	OAR	10	day						
Luxembourg	OAR	in due time		not monitored					no fixed delay, based on legal definition of in due time.
Norway	OAR								Reasonable amount of time prior to the interruption.
Slovenia	OS	48	hour	N/A					Decree on general conditions for the supply and consumption of electricity
Spain	GS	24/72	hour			Compensation	Max(€ 30, 10% of first full bill)	Per breach	Minimum 24 to customers; Minimum 72 to Public Administration
United Kingdom	GS	2	day				25		£ 20

* 10% from annual payments for distribution, max. 200 by LV and 400 by MV, by 4,000 HV

TABLE CQ 1.11 TIME UNTIL RESTORATION FOLLOWING FAILURE OF DSO FUSE

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Belgium-Flemish	OAR								within 2 hours
Belgium-Walloon	OS	2	hour	N/A		N/A			
Cyprus	GS	4	hour	98.4	%		8.54	Direct debit	
Czech Republic	GS	6	hour	N/A		Compensation in case of non-performance	40	upon request	
Hungary	GS	4-12	hour			Compensation	20	upon claim	4-12 hours acc. to size of the village
Italy	GS	3-4	hour			Compensation	30	Automatic in the bill	standard 3. applicable to failure of the meter if it provokes an interruption of supply
Norway	OAR								It has to be rectified without undue delay
Latvia	OAR	asap;<24	hour						
Lithuania	OAR	24/6/2.5	hour						restoration time depends on customer category
Portugal	GS	4/5/3/4*	hour			Compensation	18, 30, 18, 92*	Automatic in the bill	LV A and B areas; LV C areas; customers with electrical equipment needed for survival; Other customers*
Slovenia	OAR	24	hour	N/A					Energy law
United Kingdom	GS	3.5	hour				25		All DSOs to respond within 3 hours on working days 7 am to 7 pm, and within 4 hours on other days **

* Portugal:
- LV A and B areas: 4 hours; compensation: € 18 for LV - P<41,4 kVA; € 30 for other LV (Total annual compensations (Q11) - € 9,231)
- LV C areas: 5 hours; compensation: € 18 for LV - P<41,4 kVA; € 30 for other LV
- Customers with Electrical equipment needed for survival: 3 hours; compensation: € 18
- Other customers: 4 hours; compensation: € 92

** All DSOs to respond within 3 hours on working days 7 am to 7 pm, and within 4 hours on other days between 9 am and to 5 pm. Otherwise a £ 20 payment must be made.

TABLE CQ 1.12 TIME OF ANSWERING VOLTAGE COMPLAINT

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Belgium-Flemish	OAR								within 2 hours
Cyprus	GS	20	day	99.8	%		17.09	After claim within 10 days	working days
Czech Republic	GS	60	day	N/A		Compensation in case of non-performance	40 each day over limit, max. 1000	upon request	
Hungary	GS	30	day			Compensation	20	upon claim	30 days, excl. time of measurement
Italy	OS	10	day	14.34	day				90% LV and 95% MV reply within 10 working days; GS as from 2008
Latvia	OAR	15	day						
Lithuania	OAR	10-20	day						10 days for household customers and 20 days for all other customers
Norway	OAR								First answer within one month, and within four months the network company shall have detected who is responsible *
Portugal	GS	15 WD				Compensation	18/30/92 **	Automatic in the bill	Total annual compensations - € 156
Slovenia	OAR	8	day	N/A					Decree on general conditions for the supply and consumption of electricity
Romania	OS	30	day	day					
United Kingdom	GS						25		Visit customer premises within 7 working days or dispatch an explanation of the probable reason ***

* First answer within one month, and within four months the network company shall have detected who is responsible for rectifying the problem.

** € 18 for LV - P<41,4 kVA; € 30 for other LV; € 92 for other voltage levels

*** Visit customer premises within 7 working days or dispatch an explanation of the probable reason for the complaint within 5 working days. Otherwise a £ 20 payment must be made.

TABLE CQ 1.13 TIME FOR METER INSPECTION IN CASE OF METER FAILURE

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Belgium-Flemish	OAR								within 3-7 days
Estonia	OAR	5	day						
Hungary	GS	15 + 8	day			Compensation	20	upon claim	
Italy	OS	10	day	8.67	day				90% LV and 95% MV reply within 10 working days; GS as from 2008
Lithuania	GS	10-20	day						Less than 10 days for household customers and less than 20 days for all other customers
Poland	OAR		day						7 days from notice to dismantle meter by its owner (DSO or customer); 14 days from notice *
Slovenia	GS	10	day	n.a.					Regulator's proposal, not yet applied
Romania	OS								

* 7 days from notice to dismantle meter by its owner (DSO or customer); 14 days from notice to send the meter for inspection by DSO; time for inspection not specified (as soon as possible)

TABLE CQ 1.14 YEARLY NUMBER OF METER READINGS BY THE DESIGNATED COMPANY

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	1	pc/ year			No, unless bilateral agreements			Meter readings once a year, but only once in 3 years does this have to be done by the DSO itself
Cyprus	OAR	12/6							12 for monthly customer, 6 for the rest
Hungary	OS	1	pc/ year			-----	-----	-------	
Italy	OAR	1	pc/ year						Number of customers with at least 1 meter reading per year, including self-reading (at least 95% of customers)
Norway	OAR	3-12	pc/ year						Meter reading typically done by the customer every 3 months
Poland	OAR	1 to 12	pc/ year						In case of smart meters readings executed “online” (EHV) or once up to 4 times a day
Portugal	GS	2	pc/ year			Compensation	18/30/92	Automatic in the bill	Compensation: € 18 for LV - P<41,4 kVA; € 30 for other LV; € 92 for other voltage levels
Slovenia	OAR	1	pc/ year	N/A					
Spain	OS	Min. of 6 times a year							
Sweden	OAR	1	pc/ year						All meters are read on a yearly basis

* At least once a year, but always depending on the meter. Digital meters are checked once a day. Data accounts for 2006 and also for 2007.

TABLE CQ 1.15 TIME FROM NOTICE TO PAY UNTIL DISCONNECTION (DSO)

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	14	day			No, unless bilateral agreements			general terms and conditions
Belgium-Flemish	OAR								following legal procedure
Cyprus	OAR	7	day						working days
Hungary	OS	90	day			------	-----	------	90 days from the due date of the bill
Italy	OAR								Only rules for notice in advance before disconnection
Latvia	OAR	20	day						
Lithuania	OAR	15-10	day						15 days for household customers and 10 days for all other customers
Luxembourg	OAR	45	day	not monitored					no regulatory penalties, legal obligation
Norway	OAR	28	day						Regulated in standardised private agreements
Poland	OAR	14	day						After 1 month from settlement deadline DSO sends notice to pay; after 14 days DSO can disconnect customer
Portugal	OAR								Customer must receive a notice 10 days before the disconnection. Although, this legal obligation *
Romania	OS	55	day						
Slovenia	OAR	8	day	N/A					Decree on general conditions for the supply and consumption of electricity
Spain	OS	2	month						
Sweden	OAR								minimum 3 weeks

* Customer must receive a notice 10 days before the disconnection. Although, this legal obligation is not seen as a OS. It is a commercial rule established by Commercial Relations Code.

TABLE CQ 1.16 TIME FROM NOTICE TO PAY UNTIL DISCONNECTION (SP/USP)

	Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
		OS or GS	Quantity	Unit	Quantity	Unit		Sum in EUR	Payment method	
SP	Austria	OS	14	day						general terms and conditions
SP	Hungary	OS	90	day			-----	-----	----	
SP	Italy	OAR								Only rules for notice in advance before disconnection
SP	Latvia	OAR	15	day						
SP	Luxembourg	OAR	30	day	not yet available					no regulatory penalties, legal obligation
SP	Poland	OAR	14	day						After 1 month from settlement deadline DSO sends notice to pay; after 14 days DSO can disconnect customer
SP	Romania	OS	55	day						
SP	Sweden	OAR								minimum 3 weeks; law
USP	Estonia	OAR	52					0		
USP	Hungary	OS	90	day			-----	-----	-----	90 days from the due date of the bill
USP	Latvia	OAR	20	day						
USP	Lithuania	OAR	15-10	day						15 days for households customers and 10 days for all other customers
USP	Luxembourg	OAR	30	day	not yet available					no regulatory penalties, legal obligation
USP	Poland	OAR	14	day						After 1 month from settlement deadline DSO sends notice to pay; after 14 days DSO can disconnect customer
USP	Romania	OS	55	day						
USP	Slovenia	OAR	8	day	N/A					Decree on general conditions for the supply and consumption of electricity

TABLE CQ 1.17 TIME OF RESTORATION OF POWER SUPPLY FOLLOWING DISCONNECTION DUE TO NON-PAYMENT (DSO)

Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
	OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
Austria	OS	1	day			No, unless bilateral agreements			next working day at the latest - general terms and conditions
Belgium-Flemish	OAR								following legal procedure
Cyprus	OAR	1	day	99.3	%				working day
Czech Republic	GS	2	day	N/A		Compensation in case of non-performance	40/120	upon request	Compensation: 40 max. 1,000 by LV , 120 max. 3,000 by MV and HV
Hungary	GS	24	hour			Compensation	20	upon claim	
Italy	GS	1	day	0.36	day		€ 30 LV domestic, € 60 LV non dom.	Automatic	As from 2008, 1 working day in case of power reduction instead of disconnection *
Latvia	OAR	3	day						
Lithuania	OAR	5-2	day	1.5-0.7					5 working days for household customers and 2 working days for all other customers
Luxembourg	OAR	3	day	not yet available (report only in autumn)					no regulatory penalties, legal obligation
Poland	OAR								As soon as possible after receipt of payment
Portugal	GS	until 17h00 of next wd				Compensation	€ 18 LV - P<41,4 kVA; € 30 other LV	Automatic in the bill	8 hours, € 92 automatic compensation for other (non LV) customers
Romania	OS	2	day						
Slovenia	OAR	3	day	N/A					Decree on general conditions for the supply and consumption of electricity
Spain	GS	24	hour			Compensation	Max (€ 30, 10% of first full bill)	Per breach	

* As from 2008, 1 working day in case of power reduction instead of disconnection (done through smart meters) excluding Sunday

TABLE CQ 1.18 TIME OF RESTORATION OF POWER SUPPLY FOLLOWING DISCONNECTION DUE TO NON-PAYMENT (SP/USP)

	Country	Type of standard	Standard		Actuals in 2007		Compensation in case of non-performance			Remark
		OS or GS	Quantity	Unit	Quantity	Unit	Type	Sum in EUR	Payment method	
SP	Austria	OAR	immediately							general terms and conditions
SP	Czech Republic	GS	2	day			Compensation in case of non-performance	40/120	upon request	Compensation: 40 max. 1,000 by LV , 120 max. 3,000 by MV and HV
SP	Hungary	GS	24	hour			Compensation	20	automatic	
SP	Latvia	OAR	3	day						
SP	Luxembourg	OAR	immediate notification to DSO		not yet available					legal obligation
SP	Poland	OAR								As soon as possible after receipt of payment
SP	Romania	OS	2	day						
USP	Czech Republic	GS	2	day			Compensation in case of non-performance	40/120	upon request	Compensation: 40 max. 1,000 by LV , 120 max. 3,000 by MV and HV
USP	Estonia	OAR	120	hour				0		
USP	Hungary	GS	24	hour			Compensation	20	automatic	
USP	Latvia	OAR	3	day						
USP	Luxembourg	OAR	immediate notification to DSO		not yet available					legal obligation
USP	Poland	OAR								As soon as possible after receipt of payment
USP	Romania	OS	2	day						
USP	Slovenia	OAR	3	day	N/A					Decree on general conditions for the supply and consumption of electricity