5TH CEER BENCHMARKING REPORT ON THE QUALITY OF ELECTRICITY SUPPLY 2011

CEER

Council of
European
Energy
Regulators

5th CEER Benchmarking Report on the Quality of Electricity Supply 2011

Preface

European Energy Regulators, working through the Council of European Energy Regulators (CEER), promote well-functioning and competitive EU energy markets so that consumers get fair prices, the widest choice of supplier and the best quality of supply possible. This quality can be measured by the number and duration of power cuts; the power surges or dips which affect our electronic equipment; or the timeliness and efficiency of the customer service provided by electricity companies.

As part of our joint efforts to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market, since 2001 we have undertaken in depth benchmarking and analysis of the quality of electricity supply in Europe, with a focus on three types of quality: continuity of supply, voltage quality and commercial quality. Indeed, as energy regulators, one of our duties is to ensure that energy companies are providing value for money for a quality product (both technically and commercially). Monitoring the quality of supply is an essential tool in the overall monitoring of a functioning electricity market, and it is our job to strike a balance between cost efficiency and quality of supply, using a variety of regulatory instruments.

Through our series of Benchmarking Reports on the Quality of Electricity Supply, CEER seeks to disseminate information on the regulation of quality of supply and on the effects produced by this regulation in individual countries. It is as much an exercise in sharing good practices as it is in promoting continuing improvements to European energy regulation and quality standards. Over the years, we can see a positive trend across Europe towards improved quality and regulation in this area and we firmly believe that our collective work has greatly contributed to such developments.

We are very pleased that our commitment to detailed and extensive analysis of these issues continues to grow and expand. In this 5th edition, we have introduced information from ten new countries, with several case studies on the situation in Switzerland and a dedicated annex on quality of supply in the nine Energy Community contracting parties. In keeping with our dedication to the importance of the quality of the supply of electricity, the report analyses progress made since the last edition (4th Report) in 2008 and provides a series of concrete recommendations for further improvements in the regulation of the quality of electricity supply.

We hope you will find the data and analysis of interest and that the report is useful for your work. Should you require greater insight into any part of this report, we invite you to contact CEER or your national energy regulators for further information.

The Lord Mogg
CEER President
Brussels, April 2012

List of abbreviations

Term	Definition
ACER	Agency for the Cooperation of Energy Regulators
AEEG	Autorità per l'energia elettrica e il gas (Italian energy regulator)
AIT	Average Interruption Time
AMI	Advanced Metering Infrastructure
AMM	Automated Meter Management
ASIDI	Average System Interruption Duration Index
ASIFI	Average System Interruption Frequency Index
BR	(CEER) Benchmarking Report (on Quality of Electricity Supply)
CAIDI	Customer Average Interruption Duration Index
CAIFI	Customer Average Interruption Frequency Index
CEE	Central East Europe
CEER	Council of European Energy Regulators
CEMI	Customer Experiencing Multiple Interruptions (Sweden)
CENELEC	European Committee for Electrotechnical Standardization
CI	Customer Interruptions (United Kingdom, Ireland)
CIGRE	International Council on Large Electric Systems
CIRED	International Conference on Electricity Distribution
CML	Customer Minutes Lost (United Kingdom, Ireland)
CoS	Continuity of Supply
CP	Contracting Party
CQ	Commercial Quality
CRM	Customer Relationship Management
CTAIDI	Customer Total Average Interruption Duration Index
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
ECRB	Energy Community Regulatory Board
EHV	Extra High Voltage
ElCom	Eidgenössische Elektrizitätskommission (Swiss National Regulator Authority)
EMC	Electromagnetic compatibility
EnC	Energy Community
END	Energy Not Distributed
ENS	Energy Not Supplied
ERSE	Entidade Reguladora dos Serviços Energéticos / Energy Services Regulatory Authority (Portuguese National Regulatory Authority)
EQS TF	(CEER) Electricity Quality of Supply and Smart Grids Task Force
ERGEG	European Regulators Group for Electricity and Gas
EU	European Union
EURELECTRIC	Eurelectric - Union of the electricity industry
GGP	Guidelines of Good Practice
GIS	Geographic Information System
GS	Guaranteed Standard
HV	High Voltage
IEC	International Electrotechnical Commission
IEEE	(formerly) Institute of Electrical and Electronics Engineers
LV	Low Voltage
MAIFI	Momentary Average Interruption Frequency Index
MAIFIE	Momentary Average Interruption Event Frequency Index
MO	Meter Operator
MV	Medium Voltage
NA	Not Applicable
NIEPI	"Equivalent number of interruptions related to the installed capacity" (Spain, Portugal)

Term	Definition
NRA	National Regulatory Authority
NVE	Norges Vassdrags - og Energidirektorat (Norwegian energy regulator)
OAR	Other Available Requirement
Ofgem	Office of Gas and Electricity Markets (Great Britain energy regulator)
OM	Only Monitoring
OS	Overall Standard
PQ	Power Quality
r.m.s.	Root mean square
RAs	Regulatory Authorities
R-ENS	Regulated Energy Not Supplied (Italy)
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SEE	South East Europe
SP	Supplier
Ssc	Short circuit power
THD	Total Harmonic Distortion
TIEPI	"Equivalent interruption time related to the installed capacity" (Spain, Portugal)
T-SAIDI	Transformer System Average Interruption Duration Index (Finland)
T-SAIFI	Transformer System Average Interruption Frequency Index (Finland)
TSO	Transmission System Operator
UCTE	Union for the Coordination of the Transmission of Electricity
Un	Nominal voltage
USP	Universal Supplier
VQ	Voltage Quality
VQM	Voltage Quality Monitoring
VQMS	Voltage Quality Monitoring System
VSE	Association of Swiss Electricity Companies
wd	working day

List of Country Abbreviations used in the Report

Abbreviation	Full country name
AL	Albania
AT	Austria
BE	Belgium
BA	Bosnia and Herzegovina
BG	Bulgaria
HR	Croatia
CY	Cyprus
CZ	Czech Republic
DK	Denmark
EE	Estonia
FI	Finland
FR	France
DE	Germany
GR	Greece
HU	Hungary
IS	Iceland
IE	Ireland
IT	Italy
LV	Latvia
LT	Lithuania
LU	Luxembourg
MK	The Former Yugoslav Republic of Macedonia (FYR of Macedonia)
MT	Malta
ME	Montenegro
NL	The Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
SK	Slovak Republic
SI	Slovenia
ES	Spain
SE	Sweden
UA	Ukraine
UNMIK	The United Nations Interim Administration Mission in Kosovo
UK	United Kingdom (GB is used for Great Britain: England, Scotland and Wales)

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CEER

The Council of European Energy Regulators (CEER) is the voice of Europe's national regulators of electricity and gas at EU and international level. Through CEER, a not-for-profit association, the national regulators cooperate and exchange best practice. A key objective of CEER is to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market that works in the public interest.

CEER works closely with (and supports) the Agency for the Cooperation of Energy Regulators (ACER). ACER, which has its seat in Ljubljana, is an EU Agency with its own staff and resources. CEER, based in Brussels, deals with many complementary (and not overlapping) issues to ACER's work such as international issues, smart grids, sustainability and customer issues.

The work of CEER is structured according to a number of working groups and task forces, composed of staff members of the national energy regulatory authorities, and supported by the CEER Secretariat.

This report was prepared by the Electricity Quality of Supply and Smart Grids Task Force of CEER's Electricity Working Group.

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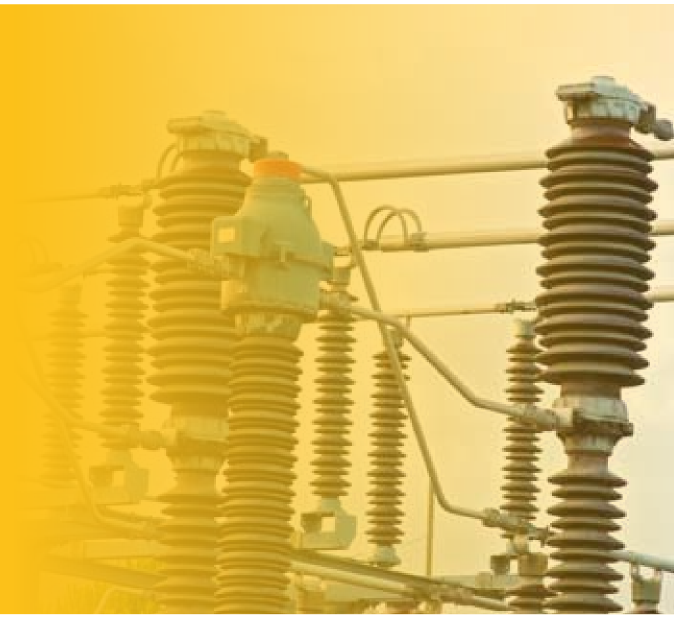
1.



Introduction

Background

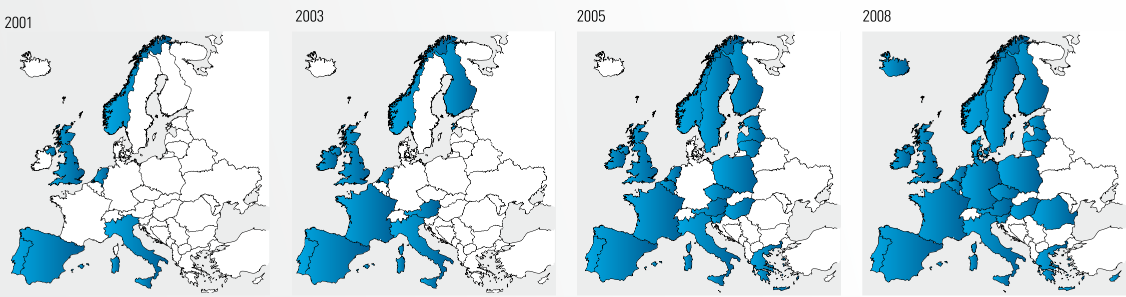
The Council of European Energy Regulators (CEER) periodically surveys and analyses the quality of electricity supply in its member countries. These surveys and analyses take the form of CEER Benchmarking Reports on Quality of Electricity Supply (hereafter Benchmarking Reports). The first report was issued in 2001 [1], followed by the second, third and fourth editions in 2003, 2005 and 2008 respectively [2] [3] [4].

CEER recommended the following activities in the First Benchmarking Report:

- publication of the report to promote discussion of quality of supply regulation amongst EU and non-EU Regulatory Authorities;
- submission of the findings for discussion at international conferences on regulatory issues;
- enlargement of the membership (6 countries) to include other countries.

The publication of these Benchmarking Reports, using a minimum common structure through all the editions, has facilitated the availability of information on the regulation of quality of supply and on the effects produced by this regulation in each country. As a result, good practices for regulating quality of

FIGURE 1.1 | Active contribution to the CEER Benchmarking Reports over its four editions (2001-2008)

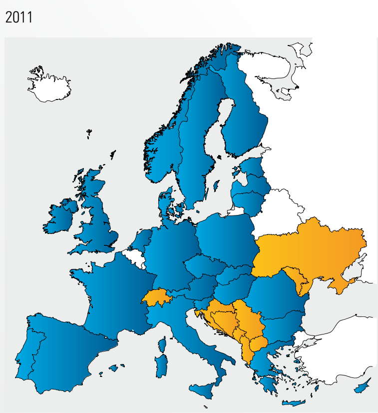


supply in electrical networks are described in the Benchmarking Reports and are adopted by many European countries. The benchmarking exercise has steadily spread to other countries as displayed in Figure 1.1, which depicts the enlargement of the participation in the previous four editions.

Expanding Coverage

In addition to National Regulatory Authorities (NRAs) from its member countries, CEER is pleased that NRAs from other European countries are joining the benchmarking practice for this 5^{th} edition. As displayed in Figure 1.2, the 9 NRAs from the Energy Community Regulatory Board (ECRB) - Albania, Bosnia and Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Moldova, Montenegro, Serbia, Ukraine and United Nations Interim Administration Mission in Kosovo have undertaken their joint benchmarking report (included as an Annex to the present report). In addition, information on continuity of supply and voltage quality aspects in Switzerland has been incorporated as case studies directly into this report (in dedicated sections of the relevant chapters), with information provided by the Swiss NRA, ElCom. The full information on national regulations and their effects in the ECRB countries is available in the annex on "Quality of Electricity Supply in the Energy Community".

FIGURE 1.2 | Active contribution to this edition of the 5^{th} Benchmarking Report (2011)



Structure

This 5^{th} Benchmarking Report addresses the three major aspects of quality of electricity supply: 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). These elements are treated in Chapter 2, Chapter 3 and Chapter 4, respectively.

Each chapter presents the results of the benchmarking activity through the following main steps:

- An explanation of the quality aspect and the importance of regulating it;
- A summary of the past activities of the European Energy Regulators, with an emphasis on the period since the publication of the 4^{th} Benchmarking Report;
- Specific details on the following topics:
  - A review of what is monitored;
  - A review of how it is monitored and regulated; and
  - Actual data and results available from monitoring and regulation.

For continuity of supply, in this edition particular focus was placed on the output (continuity)-based regulatory mechanisms and incentives currently adopted in most European countries (Section 2.8). This follows up the priority which was stated by the European Energy Regulators in the Position Paper on Smart Grids [5]: "regulators shall mainly focus on outputs, by tailored regulatory mechanisms, in their regulation of the distribution and transmission grids."

Conclusions

Each chapter concludes with a summary of CEER's main findings and recommendations regarding each quality aspect (Sections 2.9, 3.6 and 4.8).

For both, continuity of supply and voltage quality aspects, CEER has identified a common recommendation: countries use different terms to identify network users, also according to their use of networks (e.g. network users, users, customers, end-users, transmission customers, transmission users, consumers, generators, producers). This could result in misunderstandings and lack of comparability. CEER therefore recommends the harmonisation of the terms used for the regulation of continuity of supply and voltage quality, adopting following terms only: network users (in short form, users), consumers, and generators. For commercial quality, the term "customer" is deemed to describe better the relationship between the network operator or supplier as a company and the network user as a customer of this company.

2.

Continuity of Supply

2.1. What is Continuity of Supply and why is important to regulate it?

Continuity of supply concerns interruptions in electricity supply. In other words, it focuses on the events during which the voltage at the supply terminals of a network user drops to zero or nearly (practically) zero[1]. Continuity of supply can be described by various quality dimensions. The ones most commonly used are number of interruptions per year, unavailability (interrupted minutes per year) and energy not supplied (ENS) per year.

Network users expect a high continuity of supply[2] at an affordable price. The fewer the interruptions and the shorter these interruptions are, the better the continuity is from the viewpoint of the network user. Therefore, one of the roles of network operators (formerly of electric utilities) is to optimise the continuity performance of their distribution and/or transmission network in a cost effective manner. The role of the regulators in a monopolistic network condition is to ensure that this optimisation is carried out in a correct way taking into account the users' expectations and their willingness to pay.

Continuity of supply indices[3] are traditionally important tools for making decisions on the management of distribution and transmission networks. According to the quality dimensions above, regulatory instruments now mostly focus on accurately defined continuity of supply indices of 'frequency' of interruptions, 'duration' of interruptions and 'energy not supplied' due to interruptions. These instruments normally complement incentive regulation, which (either in the form of price or revenue-cap mechanisms) is commonly used across Europe at present. Incentive regulation provides a motivation to increase economic efficiency over time. However, it also carries a risk that network operators could refrain from carrying out investments and proper operational arrangements for better continuity, in order to lower their costs and increase their efficiency. To account for this drawback in incentive regulation, a large number of European regulators adopt regulatory instruments to maintain or improve the continuity of supply.

1. According to EN 50160 [22].
2. The terms 'availability of electricity supply' and 'reliability of supply' can be used with the same meaning as continuity of supply. However, this report adopts the term 'continuity of supply' as in the previous CEER Benchmarking Reports.
3. In broader terms, continuity of supply indices can be 'performance indicators' or 'output measures' of network planning, asset management and operation.

2.2. Main Conclusions from Past Activities of the European Energy Regulators on Continuity of Supply

The 1st Benchmarking Report (2001) identified the two main features of continuity of supply regulation as:

- guaranteeing that each user can be provided with at least a minimum level of quality; and
- 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 starting with long interruptions affecting low voltage (LV) network users and 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 and 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. CEER stated in the 1st Benchmarking Report that regulators need to pay attention to implementation and control issues and identified the most important implementation and control issues:

- regular internal audits by distribution companies and sample audits by the regulator; and
- accuracy and precision indicators to assist in auditing and to inform decisions about sanctions.

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 in the years 1999-2001, it was shown that some countries with historically good continuity of supply levels 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 decreases in quality of supply 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 also 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 duration and number of interruptions were able to make further improvements;
- The number of short interruptions had generally not risen despite an increased move to automation and remote control techniques.

CEER concluded in the 2nd and 3rd Benchmarking Reports that audit procedures had been put in place in almost all countries that adopted reward/penalty schemes, as measurement rules and audit procedures become more important when some kind of economic incentive is used for continuity of supply.

The handbook on "Service quality regulation in electricity distribution and retail" (developed in 2006 as a joint effort by CEER and the Florence School of Regulation) [12] listed five main ingredients for quality of supply regulation based on 5 to 10-year existing practices (in most cases from the field of continuity of supply):

- Fair and simple regulatory instruments, with clear rules on data measurement and collection;
- Adjustments of the regulatory schemes to the specific industrial and institutional factors of each country;
- Gradual approach in implementing regulatory schemes;
- Periodic evaluation and revision of the continuity regulation, with enlargements and adaptations over time but in a stable - as possible - regulatory framework;
- Efficient outcomes from an open dialogue between the regulator, the regulated companies and the network users, including learning from mistakes.

The 4th Benchmarking Report introduced precise definitions of continuity indicators in order to ensure an appropriate homogeneity between European countries. Very detailed chapters on exceptional events and a short presentation of on-site audits on continuity data were also added.

Harmonising the regulation of quality of electricity supply requires common measurement of indicators, harmonised monitoring systems, harmonised techniques for cost estimation studies and a quantification of the valuation of quality in its three dimensions (not only for continuity). With a view to optimally updating and upgrading regulatory practices which promote a single European electricity market, such harmonisation would be best undertaken at the same time as the deployment of new "smart grid" technologies. CEER has made progress in this area since the 4th Benchmarking Report, with the commissioning of a consultancy report: "Study on Estimation of costs due to electricity interruptions and voltage disturbances" elaborated by SINTEF [20] and with the publication of CEER's "Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances" (2010) [6]. Two key messages emerged:

- Results from cost-estimation studies on costs due to electricity interruptions are of key importance in order to be able to set proper incentives for continuity of supply; and
- The CEER Guidelines of Good Practice (GGP) should be used as a reference when performing a nationwide cost-estimation study, always taking into account country-specific issues and needs.

CEER representatives contributed significantly to the CENELEC technical report CLC/TR 50555:2010 "Interruption indexes" [21], issued in 2010, covering guidance on how to calculate continuity of supply indices as well as recommendations on a set of indices System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI) and Momentary Average Interruption Frequency Index (MAIFI) suitable for pan-European benchmarking of distribution network performances. This report was prepared with substantial references to previous CEER benchmarking reports on quality of electricity supply. The technical report was designed to be a first step towards benchmarking the interruption performance of European countries. The report recognised that rules on the aggregation of interruptions, in particular short interruptions, have not been considered and that it might be necessary to describe aggregation rules in a second version of the technical report.

2.3. Structure of the Chapter on Continuity of Supply

This chapter benchmarks the rules and adopted indicators to measure continuity of supply. Next, the chapter analyses the continuity of supply data provided by CEER countries, first through a comparison of national data and second through a detailed analysis of disaggregated data. Lastly, the chapter focuses on continuity standards and incentives which are (or are expected to be) adopted in CEER countries. In conclusion, CEER provides its findings and recommendations on continuity of supply.

The chapter on continuity of supply is based on input from 26 CEER countries (as reported): Austria, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom[4]. For most of these countries, a detailed look at the existing quality regulation regime is available in Section 2.8.3.

2.4. Continuity of Supply Monitoring

Continuity of supply refers to the availability of electricity to all network users. All countries who participated in this survey stated that continuity of supply is monitored within their electricity networks country-wide. This monitoring is done in differenty ways in different countries. Differences vary from the kind of interruptions monitored and the level of detail being reported to the interpretation and highlighting of various indicators. The methods used for monitoring in the different countries are presented in this section.

2.4.1. Definitions and types of interruptions monitored

In the following table (Table 2.1), differences in definitions for long, short and transient interruptions (concerning mainly the specifications for duration of an interruption) are reported for different countries.

4. Throughout this report, data for the United Kingdom is listed as Great Britain (GB).

TABLE 2.1 | Definitions of long, short and transient interruptions

Country	Transient interruption	Short interruption	Long interruption
AUSTRIA	Not defined	Not defined	T>3 min
BULGARIA	T<1 sec	T<3 min	T>3 min
CYPRUS	It is not distinguished for the moment	It is not distinguished for the moment	It is not distinguished for the moment
CZECH REPUBLIC	20 ms <T≤ 1 sec	1 sec <T≤3 min	T>3 min
DENMARK	No specific definition	No specific definition	All interruptions lasting 1 minute or more are monitored
ESTONIA	Not defined	Not defined	T>3 min
FINLAND	Not defined	T<3 min	T≥3 min
FRANCE	T<1 sec	1 sec ≤T≤3 min	T>3 min(1)
GERMANY	Not defined	Not defined	T>3 min
GREAT BRITAIN	Same as short interruptions	T<3 min	T≥3 min(2)
GREECE	Not defined	T≤3 min	T>3 min
HUNGARY	T≤1 sec	1sec <T≤3 min	T>3 min
IRELAND	Not defined	Not defined	T≥3 min(3)
ITALY	T≤1 sec	1 sec <T≤3 min	T>3 min
LATVIA	Not defined	T≤3 min	T>3 min
LITHUANIA	T<3 min	T<3 min	T≥3 min
LUXEMBOURG	Not defined	T≤3 min	T>3 min
THE NETHERLANDS	No separate definition	No separate definition	No distinction. An interruption has a duration of at least 5 seconds
NORWAY	Not used (short interruptions start at zero)	T ≤ 3 min	T>3 min
POLAND	Not defined	T≤3 min	T>3 min
PORTUGAL	Not defined	T ≤ 3 min	T>3 min
ROMANIA	T≤1 sec	1sec <T≤3 min	T>3 min
SLOVAK REPUBLIC	Not defined	T<3 min	T>3 min
SLOVENIA	Not yet. If classified (per NRA request) the guideline from EN 50160:2010 ("very Short Interruption") would be used	T≤3 min	T>3 min
SPAIN	No definition in our regulation	T≤3 min	T>3 min
SWEDEN	Not defined	100 msec <T≤3 min	T>3 min

(1) Until 2010 it was T≥3 min.
(2) This excludes re-interruptions to customers that have already been interrupted during the same incident.
(3) Up to and including 2010, this was defined as greater than or equal to 1 minute (T≥1 min).

19 countries define short interruptions. Among these countries, 12 (the Czech Republic, Finland, France, Great Britain, Hungary, Italy, Lithuania, Norway, Poland, Portugal, Slovenia and Sweden) record these interruptions separately. Meanwhile, 3 countries (Cyprus, Denmark and The Netherlands) monitor interruptions shorter than three minutes without distinction or a separate definition.

4 countries (the Czech Republic, France, Hungary and Italy) record transient interruptions separately. Some countries (Great Britain, Norway, Slovenia and Sweden) monitor transient interruptions together with the short ones (see also 2.5.2). Cyprus monitors transient interruptions together with the long ones.

2.4.2. Planned (notified) interruptions

Most countries use separate classifications for planned and unplanned interruptions. The concept "planned interruption" is cited in EN 50160 [22] (the term "prearranged interruption" is used) as an interruption for which network users are informed in advance, typically due to the execution of scheduled works on the electricity network. Most countries use this definition: advance notification is sufficient for an interruption to be classified as a planned interruption. In 1 country no distinction is made between planned and unplanned.

24 out of 26 countries (Austria, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, The Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain and Sweden) monitor planned and unplanned interruptions separately.

Whereas there is general agreement on the definition of a planned interruption, the requirement for advance notice varies strongly between countries (between 24 hours and 50 days). Definitions of planned and unplanned interruptions, rules for treatment of planned interruptions can be found in Table 2.2.

TABLE 2.2 | Planned and unplanned interruptions - definitions and rules

Country	Planned interruption	Unplanned interruption	Rules for planned interruptions
AUSTRIA	Interruptions where the grid user has to be informed in advance.	Interruptions caused by lasting or temporary disturbances, mainly related to component malfunction or external disturbances.	No (just the case of mutual agreement is described, where no loss of energy applies).
BULGARIA	Planned interruptions are connected to planned works at the request of the network operators, public providers, end suppliers and/or third parties, when the customers have been duly notified in advance.	An interruption the customer has not been informed of in advance.	For activities which are subject to planning, the company is under the obligation to inform the customer/network users about the time and duration of an electricity supply interruption through the mass media at least 14 calendar days in advance.
CYPRUS	Comply with standard definition.	Comply with standard definition.	Yes, according to rules.
CZECH REPUBLIC	Interruptions in electricity transmission network or distribution network when carrying out planned work on transmission or distribution devices according to Energy Act (mainly: maintenance, refurbishment, construction).	All interruptions in electricity transmission or distribution which are not planned interruptions (divided: failure or its removing, forced, exceptional, interruption outside system).	Transmission: 50 days ahead. Distributions: 15 days ahead.
DENMARK	At least 48 hours notice to all customers affected.	When the notice is less than 48 hours.	48 hours notice.
ESTONIA	Planned due to construction, repairing and maintenance works in network.	Due to unpredictable damages, faults in network.	Rules issued about notice to customers are affected with minimum time-lag requested.
FINLAND	Planned interruptions are notified to customers in advance.	Unplanned interruptions are not notified to customers in advance.	No rules for planned interruptions by regulator.

Country	Planned interruption	Unplanned interruption	Rules for planned interruptions
FRANCE	An interruption notified in advance to all affected customers with adequate notice.	An interruption not notified in advance to all affected customers or notified with inadequate notice.	On the transmission network, every planned interruption is planned in cooperation between TSO and impacted customers, in order to minimise the consequences for industrial customers' activity and to avoid outages for final customers of DSOs. There is a procedure for cooperation with different steps of planning starting from one year (or even more for important works) to one month before the interruption. The last confirmation is given at least 15 days before. On the distribution network, the operator must agree with MV customer a date for the planned interruption at least 10 days before the date (except in case of emergency). Planned interruptions are notified to small customers (<36kVA) by press or by individualised information.
GERMANY	Planned interruptions are interruptions with notice or arrangement in advance to the customers in an appropriate manner.	All other interruptions.	No.
GREAT BRITAIN	A planned interruption is defined as an interruption of supply where notification has been given to customers affected at least 48 hours before the interruption.	An unplanned interruption is defined as an interruption of supply to customer(s) for three minutes or longer or any occurrence on the distribution system or other connected distributed generation or transmission system that prevents a Circuit or item of equipment from carrying normal load current and where notification has not been given to customers at least 48 hours before the interruption.	At least 48 hours notice should be provided to affected customers - carding customers with the expected interruption duration, etc.
GREECE	48 hour customer notice.		No rules issued by the regulator.
HUNGARY	Planned interruption is one which all affected customers are notified of in advance.	In case of unplanned interruption, all affected customers are not notified in advance or get an adequate notice.	According to the Guaranteed Standards (and based on the law) there are two different notification rules depending on the power capacity: - with power capacity below 200 kVA customers should be notified 15 days before the planned interruption according to the local practice, e.g. leaflet. - with power capacity of 200 kVA or above customers should be notified 30 days before the planned interruption by a personal letter if there is no other agreement between the parties.
IRELAND	Monitored	Monitored	Yes. A minimum of 2 days notice must be provided.
ITALY	An interruption notified in advance to all affected customers with adequate notice.	Different than planned.	Rule for distribution network operators: advance notice of 2 working days. Advance notice reduced to 24 hours in case of interventions after faults or during emergencies.
LATVIA	Monitored	Monitored	
LITHUANIA	Monitored	Monitored	

Country	Planned interruption	Unplanned interruption	Rules for planned interruptions
LUXEMBOURG	Previous notice of interruption.	No previous notice of interruption, however, if possible, provisional length of interruption has to be communicated to the affected customers.	Network operators are legally bound to inform customers prior to the interruption as early as possible, and by appropriate means about the date and time of the planned interruption.
THE NETHERLANDS	An interruption of which the network operator has informed the affected customers at least 3 working days in advance.	An interruption that is not a planned interruption.	Yes, notice to household customers and industrial customers on the low voltage network must be given at least 3 working days in advance, but no criteria exist relating to the procedure for giving notice. Notice to industrial customers on the medium and high voltage network must be given at least 10 working days in advance and the time of the planned interruption can only be established after consultation with the customer and taking into account the interests of the customer.
NORWAY	Planned interruptions: we call them notified interruption. An interruption is considered notified if customers are informed a reasonable amount of time prior to the interruption and the information has been provided in an appropriate manner.	Unplanned interruptions: we call them non-notified interruptions. An interruption is considered non-notified if it does not fulfill the requirements for a notified interruption.	The interruption must be notified a reasonable amount of time prior to the interruption and the information shall be provided in an appropriate manner. If the interruption is not satisfactorily notified, it shall be regarded as a non-notified interruption.
POLAND	Classified as prearranged (planned), when network users are informed in advance, to allow the execution of scheduled works on the distribution system.	Classified as accidental (unplanned), caused by permanent or transient faults, mostly related to external events, equipment failures or interference without notice in advance to the customers.	A minimum of 5 days notice must be provided.
PORTUGAL	Interruption with notice in accordance with the Commercial Relations Code, published by ERSE (NRA).	Interruption without notice.	Interruptions for reasons of public interest: the entity responsible for the network must inform, whenever possible, and with a minimum prior notice of 36 hours, the customers which may be affected by the interruption. • Interruptions for service reasons: the entity responsible for the network has the duty to minimise the impact of the interruptions among customers. For this purpose, distributors may agree with the clients that will be affected the best moment for the interruption. If the agreement is not possible, the interruptions must occur, preferentially, 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 entity responsible for the network must inform with a minimum prior notice of 36 hours. • Interruptions due to customer responsibility: the supply interruption may only take place following a prior notice of interruption, with a minimum advance warning of 8 days relative to the date when it will occur. If the customer installation emits perturbations to the network, the operator establishes, in accordance with the customer, a time period for solving the problem.

Country	Planned interruption	Unplanned interruption	Rules for planned interruptions
ROMANIA	The interruption is considered planned when the customers are informed in advance, usually 15 calendar days and in special circumstances, critical operation conditions (if the interruption can however be delayed), 1 day (24 hours) notice.	The interruption is considered unplanned when the customers are not informed in advance.	Usually the planned interruptions are discussed and planned with the big customers.
SLOVAK REPUBLIC	It is not defined.	Interruption which comes into being by reason of failure or force majeure.	There are rules - minimum time for giving notice is 15 days.
SLOVENIA	According to EN 50160:2010	According to EN 50160:2010	Each customer that will be affected must be informed, using written form or any other suitable form, in a timely manner. If the interruption will affect a large number of customers, the customers must be informed by public notification (by announcement on the local radio, publication on the DSO web-pages, notification by using messaging services (SMS, MMS) etc.) at least 48 hours before the start of the interruption.
SPAIN	An interruption of continuity of supply declared by a distribution firm in advance (72 hours) to Regional Government, and authorised by this institution.	Any interruption not considered as planned interruption.	Planned interruptions must be announced to affected customers giving a minimum of 24 hours advance notice by the following means: a) By means of individualised notification using a method whereby there is a record of it having been sent to consumers shows supplies are carried out at voltages higher than 1 kV and to those establishments rendering services that are declared to be essential services, b) By means of advertising posters placed in visible spots with regard to all other consumers and by means of two of the most widely circulated printed media in the province.
SWEDEN	Interruption of the supply to take measures needed for electricity safety reasons or to maintain a food operational security of continuity of supply.	Other than planned interruption.	The interruption shall not be longer than required for the measures to be taken, When interruptions can be known in advance, and where it concerns other than short interruptions, the network operator shall inform the consumer "in time" through personal contact or, where appropriate, through a notice.

2.4.3. Voltage levels monitored

Not all countries monitor interruptions at all voltage levels, but all of them generate statistic records for incidents at more than one voltage level (Table 2.3). Medium voltage (MV) and high voltage (HV) levels are monitored in all countries. In Slovenia, monitoring on the specified levels is required and applied in general, but the data is not aggregated per particular voltage level (for purposes of reporting). The data is reported per specified network element (i.e. MV feeder, connection point, etc.) instead and can be processed ex post as needed.

Incidents in the transmission network are monitored in 21 of the 26 countries. Incidents at all voltage levels are monitored in 17 countries.

TABLE 2.3 | Voltage levels monitored in the different countries

Country	LV	MV	HV	Transmission
AUSTRIA		X	X	X
BULGARIA	X	X	X	X
CYPRUS	X	X	X	X
CZECH REPUBLIC	X	X	X	X
DENMARK	X	X	X	
ESTONIA	X	X	X	
FINLAND		X	X	X
FRANCE	X	X	X	X
GERMANY	X	X	X	X
GREAT BRITAIN	X	X	X	X
GREECE	X	X	X	X
HUNGARY	X	X	X	X
IRELAND	X	X	X	
ITALY	X	X	X	X
LATVIA	X	X	X	
LITHUANIA	X	X	X	
LUXEMBOURG	X	X	X	X
THE NETHERLANDS	X	X	X	X
NORWAY		X	X	X(3)
POLAND	X	X	X	X
PORTUGAL	X	X(1)	X	X
ROMANIA	X	X	X	X
SLOVAK REPUBLIC	X	X	X	X
SLOVENIA		X(2)	X	X
SPAIN	X	X	X	X
SWEDEN	X	X	X	X

(1) Only long interruptions monitored in distribution.

(2) Monitoring on the specified levels is required and applied in general, however, the data is not aggregated per particular voltage level (for purposes of reporting). Data is reported per specified network element (i.e. MV feeder, connection point etc.) and can be processed ex post as needed.

(3) All network above 33 kV (33-420 kV) is included in the HV category.

2.4.4. Level of detail in the calculated indicator

Continuity of supply indicators are captured for different categories, areas and levels within one country. Please refer to Table 2.4, which shows an overview of the different breakdowns for which indicators are calculated and collected. Further details are provided in the extensive footnotes.

TABLE 2.4 | Level of detail in the presentation of the indicators in the different countries

Country	National	System Operators	Region	Customer	Voltage level	Causes	Urban/ rural	Cable/ aerial
AUSTRIA	X	X			Yes[14]	Yes[33]		No
BULGARIA	X			X[1]	Yes[15]	Yes[34]		Yes[59]
CYPRUS			X[2]		Yes[16]	Yes[35]	X	Yes
CZECH REPUBLIC		X[3]			Yes[16]	Yes[36]		No
DENMARK				X[4]	Yes[17]	Yes[37]		No
ESTONIA				X[5]	Yes[18]	Yes[38]		No
FINLAND		X			Yes[19]	No[39]		No
FRANCE		X[6]		X[6]	Yes[20]	Yes[40]	X[53]	Yes
GERMANY	X	X[7]			Yes[21]	Yes[41]		No
GREAT BRITAIN		X[6]		X[6]	Yes[22]	Yes[42]		Yes[60]
GREECE		X			Yes[23]	Yes[43]	X[54]	No
HUNGARY	X	X[6]		X[6]	Yes[24]	Yes[64]		Yes
IRELAND	X[8]	X[8]			Yes[16]			
ITALY					Yes	Yes[44]	X[55]	No
LATVIA		X			No[25]	No		No
LITHUANIA		X[6]		X	Yes[16]	Yes[45]	X	Yes
LUXEMBOURG		X[3]			Yes[16]	Yes[46]		No
THE NETHERLANDS		X			Yes[32]	Yes[52]		No
NORWAY	X	X[6]		X[6]	Yes[26]	Yes[47]		Yes[61]
POLAND	X	X			No	No		No
PORTUGAL	X	X[6,9]		X[6,10]	Yes[27]	Yes[48]	X[56]	No
ROMANIA	X	X			Yes[28]	Yes[49]	X	No
SLOVAK REPUBLIC	X	X			Yes[29]	No		No
SLOVENIA	X	X[6,11]		X[6,12]	Yes[30]	Yes[50]	X[57]	No[62]
SPAIN		X[6]	X[13]	X	No	Yes[51]	X[58]	Yes
SWEDEN	X		X	X	Yes[31]			No[63]

(1) At single-customer level, distribution and transmission customers.
(2) Monitored at district level.
(3) DSO area.
(4) All kinds of customers at aggregated and single-customer level.
(5) For all customers at single-customer level.
(6) At both single-customer and system level.
(7) One indicator for LV and one indicator for MV are calculated for every DSO. These indicators are not published. Only the aggregated national indicators are published.
(8) National level. The DSO and TSO may have further breakdowns, but the NRA does not get involved in this detail.
(9) All customers.
(10) Transmission: by delivery point; Distribution: by voltage, national, district, geographical zones (Zone A, B, C).
(11) Monitoring at the single customer level is limited to customers that are subject to the compensation scheme. The number and duration of interruptions is monitored only at single customer level.
(12) Distribution: per MV feeder, per distribution area, national; Transmission: national
(13) Municipality.
(14) Interruptions are recorded on HV and MV level. Classification: EHV - network at nominal voltage level greater than 110 kV; HV - network at nominal voltage level greater than 36 kV up to including 110 kV; MV - network at nominal voltage level greater than 1 kV up.
(15) MV and HV.
(16) HV, MV, LV.
(17) LV: 0.4-1 kV, MV1: 1-25 kV, MV2: 25-70 kV, HV: 70-170 kV.
(18) HV, LV and MV, MV on different nominal voltage levels.

(19) TSO and regional network operators: 400 kV, 220 kV, 110 kV and DSOs: 1-70 kV.

(20) EHV+HV, MV, LV.

(21) EHV: Network at nominal voltage level greater than 125 kV; HV: Distribution network at nominal voltage level greater than 72.5 kV up to including 125 kV; MV: Distribution network at nominal voltage level greater than 1 kV up to including 72.5 kV; LV: Distribution network at nominal voltage level ≤ 1 kV. Data are gathered for all voltage levels but indicators are only calculated and published for LV and MV.

(22) For unplanned incidents: -132 kV damage and non-damage; -EHV (66 kV-22 kV) damage and non-damage; -HV (20 kV-1 kV). LV non-damage; LV Overhead Mains – damage; LV Underground Mains – damage; LV Switchgear – damage; LV Services overhead (excl cut-outs) – damage; LV Services underground (excl cut-outs) – damage. For planned incidents: Planned EHV; Planned HV Pole Mounted/Overhead; Planned HV Ground Mounted/Underground; Planned LV Pole Mounted/Overhead; Planned LV Ground Mounted/Underground. Incidents on the systems of NGC or the transmission companies (in Scotland); Incidents on the systems of distributed generators; and Incidents on any other connected systems – which should be identified.

(23) Interruptions originated at: (a) MV; (b) LV.

(24) LV, MV, HV and Transmission system. Interruptions are recorded according to the voltage level of the network, but LV interruptions are only recorded if a consumer reports it. Distribution level: LV: 0.4 kV, MV: 10-35 kV, HV: 120 kV; Transmission level: 220 kV-750 kV.

(25) Interruptions monitored only at specific voltage levels.

(26) [<1-22] kV; [33-110] kV; [132] kV; [220-300] kV; 420 kV.

(27) Very High Voltage (Urms > 110 kV): 400 kV, 220 kV, 150 kV, 130 kV; HV (45 kV < Urms ≤ 110 kV): 60 kV; MV (1 kV < Urms ≤ 45 kV): 30 kV, 15 kV, 10 kV, 6 kV; LV (Urms ≤ 1 kV): 230 V.

(28) Transmission level EHU:220-750 kV, distribution level: HV: 110 kV; MV:1-60 kV; LV: max 1 kV.

(29) TSO 220 and 400 kV, DSO VN>1 kV, NN<1 kV.

(30) EHV, HV (TSO) and MV (DSO) origins are covered. LV is planned to be covered starting in 2013. Additionally on the MV level, we are recording the interruptions according to the observation point (MV feeder of the substation).

(31) Separation between distribution (0.4 – 20 (130) kV) and regional networks (40 kV- 130 kV).

(32) The TSO and DSOs record the exact voltage level at the location of origin of the interruption, but this is later aggregated at the level of LV, MV and HV networks for publication in the media and for reporting to the regulator.

(33) Planned (mutual); unplanned (force majeure, damage caused by third party, system operator internal) interruption of supply.

(34) A) Planned interruptions - for planned activities; B) Unplanned interruptions - due to breakdowns, disturbances, etc.; due to/caused by TSO; - due to/caused by third parties; - due to/caused by force majeure.

(35) Planned Interruptions (Expansion of network, maintenance, rectification of network after a fault.) Unplanned Interruptions (Operational reason, weather, related human error, equipment failure.).

(36) Categories of interruption: 1. Unplanned interruptions; 1.1 Faults; 1.1.1. Caused by failure of equipment in Transmission Network or Distribution Network, or during its operation; 1.1.1.1. Under standard weather conditions; 1.1.1.2. Under severe weather conditions; 1.1.2. Caused by third party interference; 1.2 Enforced; 1.3 Exceptional; 1.4 Caused by event outside of network or by producer; 2. Planned interruptions

(37) Interruptions recorded by number and duration. Classification of causes: Planned 50%; Unplanned 100%; 3. part 10%; Force majeure 0%; Outside own voltage level

(38) List of 60 different types of causes, 2 levels what and why happened.

(39) Recording: planned and unplanned interruptions in network operators own network.

(40) Atmospheric events (lightning, snow, wind…), equipment failures (line, substation…), vegetation contact, human operation cause, customer installation cause, third party cause, non-identified cause…

(41) 1. atmospherical influence; 2. caused by third party; 3. responsibility of the network operator; 4. others; 5. feedback effects caused in other networks; 6. exchange of meter; 7. force majeure.

(42) Categories: Lightning; Rain; Snow and Ice; Freezing Fog & Frost; Wind and gale (including windborne material); Condensation; Corrosion; Mechanical shock or vibration; Ground subsidence; Flooding; Fire not due to faults; Growing or Falling Trees; Windborne Material, Disruption of intended indoor environment, Falling live trees (not felled), Falling dead trees (not felled), Growing trees, Corrosion due to atmosphere/environment, Birds (including swans and geese), Vermin, wild animals and insects, Farm and domestic animals, Wilful damage, interference or theft.

Accidental Contact, Damage or Interference by: Cable TV companies or their contractor; Public Telecoms Operator (eg. BT, Mercury etc) or their contractors; Gas Company or their contractors; water/sewage companies or their contractors; highway authorities or their contractors; farm workers or farm implements; aircraft or unmanned balloons; private individuals (excl. Aircraft/Balloons/Leisure Pursuits); unknown third parties; local building authorities or their contractors; private developers or their contractors; leisure pursuits; other third parties; and DNOC or their contractors. Switching error by DNOC staff, Testing or commissioning error by DNOC staff, Incorrect or inadequate system records, circuit labelling or identification, Corrosion due to Bi-Metal Contact, Incorrect application of equipment by DNOC staff, Faulty installation or construction by DNOC staff, Load current above previous assessment, Incorrect or Unsuitable protection settings or fuse rating, Unsuitable protection settings, Solar Heat, Inadequate rupturing or short circuit capacity, Deterioration due to ageing or wear (excluding corrosion), Fault on equipment faulting adjacent equipment, Unsuitable paralleling conditions, Failure of infeed from Adjacent Distribution Network, Operational or safety restriction, Extension of Fault Zone due to Fault Switching (including ASC held faults), Inadequate or faulty maintenance, Extension of Fault Zone due to incorrect operation of equipment (includes slow opening CB's), Failure of Supply from Generating Company or NGC, Switching Error by Contractors, Testing or commissioning error by Contractors, Incorrect application of equipment by Contractors, Faulty Installation or Construction by Contractors, Fault on customers network causing operation of Network Protection.

Interruption to remove local generator or restore temporary connections (where in use >18 hours), Local generation failure (isolated system), Distribution equipment affected by National Grid Company personnel or equipment, Distribution equipment affected by private generator or authorised electricity operator (not NGC), Faulty Classification: For each recorded incident the DNOs have to record a cause code as the reason for the incident. So if there was an incident due to a branch hitting a line and causing an interruption for customers, the DNO would put the cause code in the reporting template against this incident.

(43) Unplanned interruptions: 1. External (due to transmission system infeed loss, fires, floods etc); 2. Due to exceptional weather conditions; 3. Other. Planned interruptions: 1. System development works; 2. Maintenance works; 3. Repair work.

(44) Category: For transmission, there are four macro-categories: lack of system adequacy, force majeure, external causes (i.e. users), TSO causes. For distribution, there are three macro-categories: force majeure, external causes (i.e. users), DNO causes. Classification: For transmission, there is a 2nd level classification (about 15 causes) and 3rd level classification (about 50 causes). For distribution, a 2nd level classification was recently proposed to enter into force in 2012 (about 20 causes).

(45) 1. Force majeure; 2. External causes; 3. Causes attributable to system operator responsibility; 4. Non - identified causes.

(46) Currently under redefinition; (more detailed regulations will enter in force in the beginning of the second quarter of 2011).

(47) Main categories: 1- surroundings; 2- people (staff); 3- people (others); 4- operational stress; 5- technical equipment; 6- design/ installation; 7- others; 8- cause unknown. These main categories are further divided into subcategories. In audits, NVE emphasises the importance of trying to avoid using the category "cause unknown".

(48) The Commercial Relations Code, published by ERSE, establishes the situation in which supply can be interrupted (some of them are planned and others unplanned): Force majeure, due to the customer, security reasons, working reasons and public interest. Related to unplanned interruptions, the network operators included more category causes. It is possible to identify the following types of causes: internal related to the network operator, external related to the network operator, related to the equipment, human, maintenance, environmental...

(49) a. planned; b. unplanned due to force majeure; c. unplanned due to customers; d. unplanned excluding b and c.

(50) No cause categories are applied. Classification: All interruptions must be classified into one of the categories. Unidentified causes are attributed to the DSO/TSO (responsibility of DSO/TSO). Slovenia doesn't categorise the cause of short interruptions.

(51) For planned interruptions: transmission and distribution. For unplanned interruptions: Third party, generation, transmission, force majure, distribution.

(52) Manufacturer, network design, assembly, operation, aging/wear, external influence (e.g. excavation works), soil movement, moisture, weather, operational stress, internal defect, unknown.

(53) There are three types of areas: 1. Zone A: customers living in or close to large cities (>100,000 inhabitants); 2. Zone B: customers living in or close to medium cities (>10,000 inhabitants); 3. Rural zone.

(54) No classification exists for urban and rural areas. The criteria for the definition of a distribution area are administrative.

(55) Urban: cities more 50,000 inhabitants; Mid: 5,000 < inh. < 50,000; Rural: villages less 5,000 inhabitants.

(56) Since 2006: Zone A (Urban): main cities and localities with more than 25,000 customers; Zone B (Semi-urban): locality with less than 25,000 and more than 2,500 customers; Zone C (Rural): locality with less than 2,500 customers.

(57) Each MV feeder is classified by type (urban, mixed, rural): urban type: 2/3 of all connected customers must be located in urban settlements; rural type: 2/3 of all connected customers must be located outside the urban settlements; mixed type: cannot be classified as one of the above types. The classification of settlements is based on the standardised methodology defined by Statistical Office of the Republic of Slovenia ("Urban settlements in the Republic of Slovenia", 2003): the combined criteria is applied, using a threshold of 3,000 inhabitants for an urban settlement as a "core" criteria. Three additional criteria are applied allowing even smaller settlements to classify into urban in case they have a surplus of registered workplaces over the number of active (employed) persons.

(58) Urban: Supplies > 20,000 (Capital Cities Included); Rural: 200 < Supplies < 2,000.

(59) There is interruption data available for cable, overhead lines, transformer stations and substations.

(60) Overhead lines; Underground cables; Submarine cables; Ground-mounted circuit breakers; All other ground-mounted switchgear; Pole- or structure-mounted circuit breakers; All other pole- or structure-mounted switchgear; Ground-mounted power transformers, reactors.

(61) Data are also reported separately for different network IDs: distribution network - overhead lines, distribution network - cables, distribution network - mixed, regional grid and central grid. In this context, networks mean installation components protected by the same circuit breaker/fuse. Definition of Network IDs: Distribution network: network with a nominal voltage up to and including 22 kV (included LV), unless otherwise decided; Overhead line distribution network: network where more than 90% of the network consists of overhead lines (measured in km); Cable distribution network: network where more than 90% of the network consists of cable (measured in km); Mixed distribution network: network which consists of less than 90% overhead lines and cables (measured in km); Regional grid: network between the central grid and the distribution network; Central grid: installations in the network at a voltage level of 132 kV or higher that are defined as installations in the central grid (individual decision by the regulator). Each reporting point (and each customer) is defined with a network ID.

(62) Following characteristics of the electricity network that is correlated with the continuity data are used: - percentage of underground cable; - percentage of overhead lines.

(63) Characteristics for the electricity network that can be correlated with the continuity data are percentage of underground cable and percentage of overhead lines.

(64) The classification of causes is made by the DSOs.

2.4.5. Measurement techniques

Nearly half of the countries use automatic logging or automatic identifications when measuring long and short interruptions (Table 2.5). Several countries use both.

TABLE 2.5 | Measurement techniques for long and short interruptions

Country	Identification of network users affected	Automatic identification	Automatic logging
AUSTRIA	No common rules.	No	No
BULGARIA	There is no automatic identification of affected customers.	No	No
CYPRUS	Yes there is a rule for estimating the customers affected. (Assumption is 1 customer for every 2 kVA).	Yes	No
CZECH REPUBLIC			No
DENMARK	No common rules.	No	No
ESTONIA	Automatic identification of customers affected for interruptions on MV level, on basis of messages from customers on LV level via GIS (geographic information system).	Yes	Yes
FINLAND	Customers are identified only by sorting them into different voltage levels.	No	No
FRANCE	On the transmission network, each customer's substation feeding is individually monitored. On both transmission and distribution systems, network system and commercial system are connected.	Yes	Yes
GERMANY	There is no standardised way of identifying the customers affected. The way of estimating differs from network operator to network operator.	No	No
GREAT BRITAIN	Ofgem collects data at a system level for each of the 14 licensed electricity distribution businesses. Ofgem also collects disaggregated data for each MV circuit so that comparisons can be made across the distribution businesses.	Yes	Yes
GREECE	For interruptions originating at MV, the number of customers affected is estimated through the interrupted MV/LV transformer installed power. For interruptions originating at LV, the number of customers affected is estimated through the rated current of the interrupted LV line fuse.	Yes	No
HUNGARY	The practice to date has been to estimate the number of customers affected. But the NRA is issuing a decision on determination of number of customers affected, which will lay down the rules for estimation from 1 January 2012.	No	No
IRELAND	This level of detail is not specified by the NRA.		
ITALY	For transmission, the sources of data/info include: the remote control system, the SCADA, the log of the remote control system, other recording systems, registrations by EHV-HV users, registrations by the distribution network operators. For distribution: the remote control system or other systems (for the MV network); various options are allowed for recording LV customers affected (the simplest refer to average number of customers, the most complex involves the single LV smart meters).	Yes	Yes
LATVIA		No	No

Country	Identification of network users affected	Automatic identification	Automatic logging
LUXEMBOURG	HV, MV: Details in DSOs system. LV: Currently average number per transformer.	Yes	Yes
THE NETHERLANDS	Identification of affected customers mostly occurs through well-established and documented methods of estimation, which are part of a national system for the registration of interruptions.	Yes	Yes
NORWAY	The standardised system for reporting interruption data (FASIT) uses data from the Customer Information System regarding exactly how many customers are connected to each of the distribution transformers affected by an interruption. The customers are divided into 36 different end-user groups, and two sub-groups (extended from 27 to 36+2 from 2008), and the interruptions are monitored for all the 36+2 end-user groups. (The 36+2 end-user groups are distributed on the 6 different customer categories.), TSO/DSO network areas, counties and the country as a whole.	Yes	Yes
POLAND	The customers at LV level are estimated and at the other higher levels are all identified.	No	No
PORTUGAL	The customers at a higher level than LV are all identified. The customers at LV are all identified if the fault affects all phases. If the fault affects only 1 or two phases, only the customers that claim are identified.	No	No
ROMANIA	An automatic system of calculation is in progress, until end of 2012, in order to record the interruptions for the customers of HV and MV level.		Yes
SLOVAK REPUBLIC	No common rules.	No	No
SLOVENIA	Identification is performed by the automatic binding of the number of affected customers through the entity properties in SCADA (i.e. substation, feeder properties etc.). This applies on the EHV, HV and MV levels. For LV (not yet covered) Slovenia is planning to use either the call-centres or AMI (SmartGrids) services. Exemptions: some cases have been identified where the meta data in SCADA is not complete or not up-to-date. In such cases, the operator performs manual mapping in post-processing phase (applying the data from external source).	No	Yes
SPAIN	Each customer is associated to a transformation centre or element in the distribution network. Each interruption in this element is associated with the customer.		Yes
SWEDEN	Connectivity model is used. Yearly interruption reported at single customer level.	Yes (for >90% of network users)	Yes (for >90% of network users)

Case Study 1

Continuity of supply monitoring and indicators in Switzerland

General Information

The Swiss Federal Electricity Commission (ElCom) asked the distribution system operators (DSOs) for continuity of supply data for the first time in 2009. Based on Article 6 paragraph 2 of the Swiss electricity decree (Stromversorgungsverordnung), the DSOs provided this information to ElCom in order to calculate the continuity indicators SAIDI and SAIFI. The calculation principles of the indices are identical to the principles used in other European countries and as described in CEER's 4th Benchmarking Report. ElCom also collects ENS index for interruption at HV and MV levels.

Since this was the first time an authority asked for such data in Switzerland, where there are about 700 DSOs, ElCom decided only to require the data from DSOs with more than 200 GWh energy supply. This concerned 46 DSOs, which represents 75% of the energy supplied by all Swiss DSOs. In 2010, the number of DSOs required to monitor continuity data was increased to 83. This number of DSOs represents about 87% of the energy supplied by all Swiss DSOs.

Data collected

The data is collected yearly. The DSOs upload their sheets to the ElCom web portal. The following table gives an overview of the type of data required in 2009 and 2010, as well as the requirements for 2011.

Continuity of Supply Reporting in Switzerland: required data	2009	2010	2011
General data			
Total number of customer in supply area	X	X	X
Total of supplied electric energy (period of evaluation)	X	X	X
Surface area of supply (in km²)	X	X	X
Type of interruption			
Beginning and end of the interruption	X	X	X
All kind of interruptions (no minimal or maximal duration)	X		
Only long interruptions (3' or longer)		X	X
Consequences			
Number of customers affected	X	X	X
ENS (unspecific)	X		
ENS at HV and MV levels		X	X
Cause of interruption			
Planned	X	X	X
Unplanned (for 2009 and 2010 not detailed specified)	X	X	X
Caused by an other DSO (if yes, by whom)	X	X	X
Natural phenomena			X
Human behaviour			X
Operational cause			X
External cause			X
Other cause			X
Force majeure (exceptional events)*	X	X	X
Highest voltage level in which outage affected one network element (all voltage levels except Extra High Voltage (EHV))	X	X	X

* The definition of force majeure (exceptional events) is according to the distribution code in Switzerland (Source: Swiss association of Electric utilities).

Results for the years 2009 and 2010

Interruptions	2009	2010
Unplanned		
SAIFI	0.3	0.2
SAIDI	18 Min.	7 Min.
Planned	No distinction between planned and unplanned interruptions	
SAIFI		0.1
SAIDI		7 Min.

The results shown above include all long (3 minutes and longer) interruptions, including exceptional events.

With regard to the significance of the analysis and the comparability between the network operators, exceptional events and not exceptional events were not distinguished in 2009 and 2010. In 2009, planned and unplanned interruptions were not distinguished for the same reason.

Reliability of data

The analysis has shown that the continuity data provided could be improved with regard to completeness, uniformity and level of detail. Currently there is no mechanism in place which allows verification of the data provided.

Future challenges

Firstly, the quality of the data collected needs to be improved. In the future, the following criteria should be considered:

- territorial network classification
- differences between cables and aerial lines
- age of the network assets

2.5. Continuity of Supply Indicators

24 out of 26 countries use indices to monitor both frequency and duration of long interruptions, for both planned and unplanned interruptions, with the additional features reported in Table 2.6. Luxembourg and the Slovak Republic do not use any indices for long planned interruptions.

TABLE 2.6 | Monitoring long interruptions in the different countries

Country	Long planned interruptions voltage levels	Long unplanned interruptions voltage levels
AUSTRIA	Occurrence: HV, MV Customers: all voltage levels	Occurrence: HV, MV Customers: all voltage levels
BULGARIA	The data is available for MV and HV depending on the type of the two networks to which the customers are connected.	The data is available for MV and HV depending on the type of the two networks to which the customers are connected.
CYPRUS	HV, MV, LV	HV, MV, LV
CZECH REPUBLIC	All voltage levels.	All voltage levels.
DENMARK	HV, MV, LV	HV, MV, LV
ESTONIA	HV, MV, LV	HV, MV, LV
FINLAND	1-70 kV, 110 kV, 220 kV and 400 kV	1-70 kV, 110 kV, 220 kV and 400 kV
FRANCE	Customers connected to distribution networks only (MV + LV).	Available for all voltage levels, separately for each voltage level with respect to where the customer is connected.
GERMANY	All voltage levels. Frequency and duration indices are gathered, but not published.	All voltage levels. Frequency and duration indices are gathered, but not published.
GREAT BRITAIN	At all voltages. Both frequency and duration indices are gathered, but not published.	At all voltages. Both frequency and duration indices are gathered, but not published.
GREECE	MV and LV with respect to where the incident occurs.	MV and LV with respect to where the incident occurs.
HUNGARY	It applies for LV, MV and HV customers with respect to where the incident occurs.	It applies for all LV, MV, HV customers.
IRELAND	Duration and number of interruptions per customer are reported to the NRA on an average (but not specific customer) basis. The information provided to the NRA for CIs and CMLs shows numbers affected with respect to where (defined by HV, MV and LV) the incident occurs. CI information shown by voltage level at which the customer was connected is also available.	Duration and number of interruptions per customer are reported to the NRA on an average (but not specific customers) basis. The information provided to the NRA for CIs and CMLs shows numbers affected with respect to where (defined by HV, MV and LV) the incident occurs. CI information shown by voltage level at which the customer was connected is also available.
ITALY	HV, MV, LV	HV, MV, LV
LATVIA	HV, MV, LV	HV, MV, LV
LITHUANIA	Indices for both frequency and duration.	Indices for both frequency and duration.
LUXEMBOURG	None	No consistent data available until 2010. Now: HV, MV, partially LV.
THE NETHERLANDS	Planned interruptions are recorded at all voltage levels, but in practice only occur in the LV and MV networks. The data that is reported to the NRA makes a distinction between the voltage levels that the customers are connected to (at an aggregated level: LV, MV, HV and EHV). The NRA has no information about the location where the planned interruption takes place.	This applies to all voltage levels. The NRA only receives information concerning the voltage level that the customers are connected to. The NRA has no information regarding the location of origin of the unplanned interruption.

Country	Long planned interruptions voltage levels	Long unplanned interruptions voltage levels
NORWAY	With respect to where the incident occurs: All voltage levels above 1 kV. With respect to where the customers are connected: All network IDs (LV also) - see description of the defined network IDs in footnote # 61 in Table 2.4.	With respect to where the incident occurs: All voltage levels above 1 kV. With respect to where the customers are connected: All network IDs (LV also) - see description of the defined network IDs in footnote # 61 in Table 2.4.
POLAND	All voltage levels of transmission or distribution systems.	All voltage levels of transmission or distribution systems.
PORTUGAL	All voltage levels, all customers, transmission, distribution. (In practice, in transmission there are no long planned interruptions. All planned interventions are done without interrupting customers).	All voltage levels, all customers, transmission, distribution.
ROMANIA	HV, MV, LV with respect to where the customers are connected.	HV, MV, LV with respect to where the customers are connected.
SLOVAK REPUBLIC	None	TSO 220 and 400 kV, DSO VN>1 kV, NN<1 kV
SLOVENIA	Transmission networks: aggregated values for EHV and HV Distribution networks: MV level (per MV substation feeder, calculated on different levels (MV feeder, distribution area, DSO)). Aggregation on the distribution area (DSO) is also performed.	Transmission networks: aggregated values for EHV and HV. Distribution networks: MV level (per MV substation feeder, calculated on different levels (MV feeder, distribution area, DSO). Aggregation on the distribution area (DSO)) is also performed.
SPAIN	All incidents over 1 kV, and they are assigned to customers using their connection with the network. For low voltage customers below 1 kV, it is used the transformation centre.	All incidents over 1 kV, and they are assigned to customers using their connection with the network. For low voltage customers below 1 kV, it is used the transformation centre.
SWEDEN	For regional networks (20 kV-130 kV) and local distribution networks (0,4 kV- 130 kV).	For regional networks (20 kV-130 kV) and local distribution networks (0,4 kV- 130 kV).

2.5.1. Long interruptions

An overview of the different indices used in the different countries to quantify the number of long interruptions is given in Table 2.7. The definitions of the different indices are given in the 4th Benchmarking Report for distribution and transmission systems (please see the List of Abbreviations). The table also gives information on the weighting method used. SAIDI and SAIFI are the most commonly used indices with weightings in most countries based on the number of network users. ENS is mostly used for transmission networks.

TABLE 2.7 | Indices used in the different countries to quantify long interruptions

Country	Index	Weighting
AUSTRIA	SAIDI, SAIFI, ASIDI, ASIFI, CAIDI, (CML, ENS)	By the power affected. By transformer stations affected; improvement of quality of data for weighting by number of customers is ongoing.
BULGARIA	SAIDI, SAIFI	By the number of customers.
CYPRUS	SAIDI, SAIFI, per cause, per voltage, percentage indicators, lost MVAs per cause, affected consumers, faults per type, faults per location, faults per substation/feeder, Average time for restore of supply, Time interval for restore of supply.	By the power affected.
CZECH REPUBLIC	Distribution: SAIFI, SAIDI, CAIDI Transmission: ENS, average duration of one interruption per year (sum of duration divided by number of interruptions).	DSO - by the number of customers, TSO – by the power affected.
DENMARK	SAIDI, SAIFI, ENS	By type of interruption and number of customers.
ESTONIA	SAIDI, SAIFI, CAIDI, total annual interruption time for each customer.	By the number of customers.
FINLAND	DSOs: in 1-70 kV: T-SAIDI and T-SAIFI, < 1 kV: amount of interruptions. TSO and regional network operators: In 400 kV, 220 kV and 110 kV: duration of interruptions and amount of interruptions at connection points.	Weighted by the annual energy consumption.
FRANCE	Transmission: AIT, SAIFI and ENS Distribution: SAIFI, SAIDI and "Percentage of customers with insufficient quality of supply" (the definition of a "customer with insufficient quality of supply" depends on the location) There are several versions of each of these indicators, depending on the type of disconnection (planned/unplanned), the voltage level, the cause (exceptional event included or not), …	Depends on the indicator.
GERMANY	SAIDI (LV), ASIDI (MV), SAIFI	LV: Number of customers; MV: rated apparent power of the affected power transformer.
GREAT BRITAIN	The two main indicators are Customer Interruptions and Customer Minutes Lost.	By the number of customers.
GREECE	SAIDI, SAIFI	By the number of customers.
HUNGARY	Distribution level: the indicators used in IEEE Std. 1366-2003: SAIDI, SAIFI, CAIDI for both planned and unplanned interruptions. Transmission level: AIT ENS/ES (Outage rate) and unavailability of transmission lines.	By the number of customers.
IRELAND	CML & CI	For distribution, the CIs and CMLs are reported on an average customer basis. For transmission, the system minutes lost indicator is related to the power affected.

Country	Index	Weighting
ITALY	For transmission: ENS, ENW, AIT, SAIFI. For distribution: SAIDI, SAIFI.	For distribution: by the number of customers affected. For transmission: number indicators are referred to transmission users.
LITHUANIA	TSO - ENS, AIT DSO - SAIDI, SAIFI	By the number of customers. ENS, AIT - interrupted power
LUXEMBOURG	More detailed regulations have entered in force on 20 May 2011. Final set of indicators will be determined after first data evaluation.	
THE NETHERLANDS	SAIDI, SAIFI and CAIDI.	By the number of customers.
NORWAY	With reference to end users (all voltage levels): SAIDI, SAIFI, CAIDI, CTAIDI, CAIFI, interrupted power per incident and ENS. With reference to reporting points (i.e. distribution transformer or a customer connected above 1 kV): Number and durations.	By the number of customers.
POLAND	Distribution level according to the IEEE Std. 1366-2003: SAIDI, SAIFI. Transmission level: ENS, AIT and according to the IEEE Std. 1366-2003 SAIDI, SAIFI.	By the number of customers.
PORTUGAL	Transmission: ENS, AIT, SAIFI, SAIDI, SARI Distribution: END, AIT (TIEPI), SAIFI MV, SAIFI LV, SAIDI MV, SAIDI LV	SAIFI and SAIDI: weighted by delivered points (transmission and MV) and by number of customers (LV); TIE (Distribution – TIEPI) and END (distribution): weighted by installed power; ENS (transmission): estimated; TIE (transmission): energy not supplied and energy supplied.
ROMANIA	DSO: SAIFI, SAIDI; ENS and AIT at 110 kV level; TSO: ENS and AIT for the whole country.	At 110 kV (max distribution level) and TSO (220-750KV) use ENS and AIT; at 110 kV also SAIFI and SAIDI.
SLOVAK REPUBLIC	Average time of interruption (220 or 400 kV).	Average number of interruptions per 1 transformer on voltage level 220 – 400 kV.
SLOVENIA	Distribution: - SAIDI, SAIFI, CAIDI, CAIFI Transmission: - SAIDI, SAIFI (implicitly ENS, AIT, AIF, AID)	By the number of customers TSO: for calculation of SAIDI, SAIFI, MAIFI, weight by the number of "users" of the transmission grid: there are 3 types of transmission users: 1) HV transformation stations (counted each as 1 user, independently from number and size of transformers installed); 2) HV final consumer (large industrial customers); and 3) producers connected to transmission grid.
SPAIN	In distribution: TIEPI, NIEPI, 80% of TIEPI and 80% of NIEPI at zonal level or individual level. In transmission: ENS, AIT and facility available percentage.	By the power affected.
SWEDEN	(iv) Until now, SAIDI and SAIFI for DSOs. From 2010, interruptions data at customer level is available. This allows publication of e.g. NIS-tagged information, supplied energy, maximal supplied power, etc. at a large range of customer levels. System level indicators such as interrupted power, energy not supplied, ASIDI, ASIFI, SAIDI, SAIFI, customer experiencing multiple interruptions (CEMI), confidence interval reflecting best and worst served customers at arbitrary level, etc. can also be calculated.	By the number of customers and/or supplied energy.

2.5.2. Short and transient interruptions

12 countries (the Czech Republic, Finland, France, Great Britain, Hungary, Italy, Lithuania, Norway, Poland, Portugal, Slovenia and Sweden) reported that they collect separate data on short and sometimes even transient interruptions, as already reported in Section 2.4.1. Information on the indices for short and transient interruptions used in these countries is summarised in Table 2.8. Definitions of the various indices are given in the 4th Benchmarking Report.

The number of short interruptions per year is used in nearly all countries. Section 2.6.3 will discuss further the actual use of indices, by reviewing two formulations which depend on aggregation rules for interruption events: MAIFI and Momentary average interruption event frequency index (MAIFIE).

Some countries give separate indices for short and transient interruptions, others exclude transient interruptions and some give one index covering short and transient interruptions.

TABLE 2.8 | Indices for short and transient interruptions in the different countries which monitor them

Country	Short	Transient
CZECH REPUBLIC	CENELEC TR 50555 (Chosen points)	CENELEC TR 50555 (Chosen points)
FINLAND	In MV, amount of short interruptions (high speed automatic reclosing and delayed automatic reclosing) which are proportional to the annual amount of energy.	
FRANCE	Transmission: MAIFI Distribution: "Percentage of customers with insufficient quality of supply" (the definition of a "customer with insufficient quality of supply" depends on the location).	None
HUNGARY	Distribution level: the indicators used in IEEE Std. 1366-2003: MAIFI (for MV networks) Transmission level: no indicator.	Distribution level: the indicators used in IEEE Std. 1366-2003: MAIFI (for MV networks). Transmission level: no indicator
ITALY	For transmission: ENS, ENW (energy not withdrawn), AIT, MAIFI. For distribution: MAIFIE	For transmission: number of transient interruptions. For distribution: number of transient interruptions.
LITHUANIA	TSO - ENS, AIT DSO - SAIDI, SAIFI	DSO - MAIFI
NORWAY	Same as for long interruptions.	Included in short interruptions.
POLAND	Distribution level according to the IEEE Std. 1366-2003: MAIFI. Transmission level: there is no indicator.	NA
PORTUGAL	Transmission level: MAIFI (it is not mandatory).	
SLOVENIA	Distribution and transmission: MAIFI	
SWEDEN	MAIFIE with an period of 3 minutes for events.	NA

2.5.3. Discussion of the different indicators

From the tables shown, 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.

SAIDI and SAIFI 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 leads to different biases towards different types of network users. When weighting is based on the number of network users, each user is treated equally, independent of its size and independent of their consumption levels.

When weighting is based on interrupted power or ENS, an interruption gets a higher weighting when the total interrupted power is higher. This might be because network users with larger demand 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 and energy is biased towards network users with larger demand. As these users 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 network users.

Weighting based on number of distribution transformers is biased towards network users 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 network users.

Indices like ENS or energy not distributed (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 ENS, as there is no energy consumption during the interruptions.

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

The indices Customer Average Interruption Frequency Index (CAIFI) and Customer Total Average Interruption Duration Index (CTAIDI) give a better impression of the continuity of supply as experienced by those network users that actually experience at least one interruption. The differences in value between SAIFI and CAIFI, and between SAIDI and CTAIDI, give an impression of the spread in the number of interruptions between different network users. The distribution of number of interruptions experienced by each individual user gives this information in a more direct way, but results in more indicators, making comparisons and trend analysis more complicated.

2.6. Analysis of Continuity by National Data

European countries use different indicators and different weighting methods when evaluating interruptions. Two main groups of indicators - "*minutes lost per year*" (SAIDI, Customer Minutes Lost (CML), Average System Interruption Duration Index (ASIDI), Transformer System Average Interruption Duration Index (T-SAIDI) or "Equivalent interruption time related to the installed capacity" (TIEPI)) and "*number of interruptions per year*" (SAIFI, Customer interruptions (CI), Average System Interruption Frequency Index (ASIFI), Transformer System Average Interruption Frequency Index (T-SAIFI), or "Equivalent number of interruptions related to the installed capacity" (NIEPI)) - are collected by countries and partly presented in this chapter. Their values are compared over a number of years.

In addition to the monitoring of duration and frequency of interruptions, one can also examine whether the interruptions were planned or unplanned. For more information, please refer to Section 2.4.2 where the definitions of planned and unplanned interruptions are listed by country, as well as the rules issued on the notice to the affected network user for planned interruptions (minimum time-requested, procedures for giving notice, etc.). Which occurrences are considered an exceptional event is determined can be done in different ways. Some countries have a more statistical approach and others focus their definition on the causes of exceptional events. More information on this topic can be found in the Annex to Chapter 2 on Continuity of Supply data.

When interpreting the results and especially when comparing between countries, one should consider the differences in calculation of the indices and in the voltage levels at which incidents are monitored. Despite the difference in names and calculation methods between countries, the results are shown in the same diagrams.

2.6.1. 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 Figures 2.1 and 2.2. 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 for unplanned interruptions, excluding exceptional events. The curves per country show a smooth trend change, generally decreasing or being constant. Especially from 2004 onwards, the decreasing trend in the total amount of lost minutes (i.e. improving service quality) is no longer obvious. That being said, increases in the total number of lost minutes have been observed in a few countries. Considering the data for the period since the last Benchmarking Report period (2008, 2009 and 2010), same quality levels or a smooth general tendency for increase in quality can be observed in nearly all countries. The exception is Portugal – its value rose from 133.08 Min/Year to 172.98 Min/Year during the period from 2008 to 2010. However, it should be noted that the number of lost minutes had been decreasing in Portugal since 2001, when it was 421.86 min/year.

In some countries (e.g. Bulgaria) we observe a significant increase in quality during the last three years. A more general remark on this trend is not possible, as more historical data for these countries is not available (the earliest data available for Bulgaria, Greece, Slovenia and Romania dates to 2008 for example). German data is available since 2006; for other countries data dates back to 1999, 2001 or 2002.

Figure 2.2 shows the number of interruptions per year, excluding exceptional events. Considering data reported since the publication of the last Benchmarking Report (2008, 2009 and 2010), we can observe either constant quality levels or a smooth general tendency for an increase in quality in nearly all countries. This indicator shows the same trend as the indicator in the previous figure (minutes lost) with the exception of Portugal and Lithuania where the curve is slightly increasing. In Lithuania, the average value for 2005-2010 is constant, due to an increase between 2005 and 2007, a decrease until 2009 and again an increase during 2010. Portugal's values had been constantly decreasing between 2001 and 2006. Since 2006, the values have been increasing, but they are still much lower than the 2001 value.

Comparing the performance between different countries is further complicated as not all countries include in their statistics incidents from all voltage levels. Most of the countries declared that, in general, interruptions on all voltage levels are monitored, but at the same time data regarding long unplanned interruptions is only available for some voltage levels. The values for Austria and Bulgaria, for example, contain interruptions that affected customers in the HV and MV networks. Austria stated that the value in this figure is actually the unplanned ASIDI value (see remark in the previous section). The real value was influenced by different natural catastrophes or exceptional weather occurrences, which are excluded here (value 2002 without flood, 2006 without UCTE-blackout on 4 November, 2007 storm "Kyril", 2008 storm "Paula" and "Emma", 2009 strong winter). Romania monitors also EHV/transmission networks (220 – 750 kV), considering ENS and Average Interruption Time (AIT) for the whole country. Sweden monitors all voltage levels (transmission, HV, LV). Data reported by France, The Netherlands, Poland, Portugal, Slovenia and the United Kingdom relates to all voltage levels as well.

In Germany, interruptions on all voltage level are monitored. Indicators are calculated and published only for MV and LV level. Indicators for MV and LV include interruptions on EHV and HV if they have feedback effects on MV and LV customers. Interruptions on EHV and HV without any effects on MV and LV customers are not considered in MV and LV indicators. Hence, the indicators for MV and LV contain interruptions of all voltage levels that affected customers at MV or LV level.

EHV (transmission network) is not monitored in Denmark, Greece, Ireland and Lithuania. In France, only data for one distributor (covering over 95% of the country) was reported. Greece reported figures that refer to the interconnected distribution network (MV & LV); non-interconnected islands are not included. Greece also reported that SAIDI & SAIFI values for 2003 are not comparable to more recent data, due to methodological differences. Ireland reported storm adjusted values for the entire distribution network.

From 2010, Sweden distinguishes between interruptions shorter than 12 hours and those longer than 12 hours. Only interruptions shorter than 12 hours are accounted for in the tariff regulation,

FIGURE 2.1 | Unplanned long interruptions excluding exceptional events; minutes lost per year (1999 - 2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur

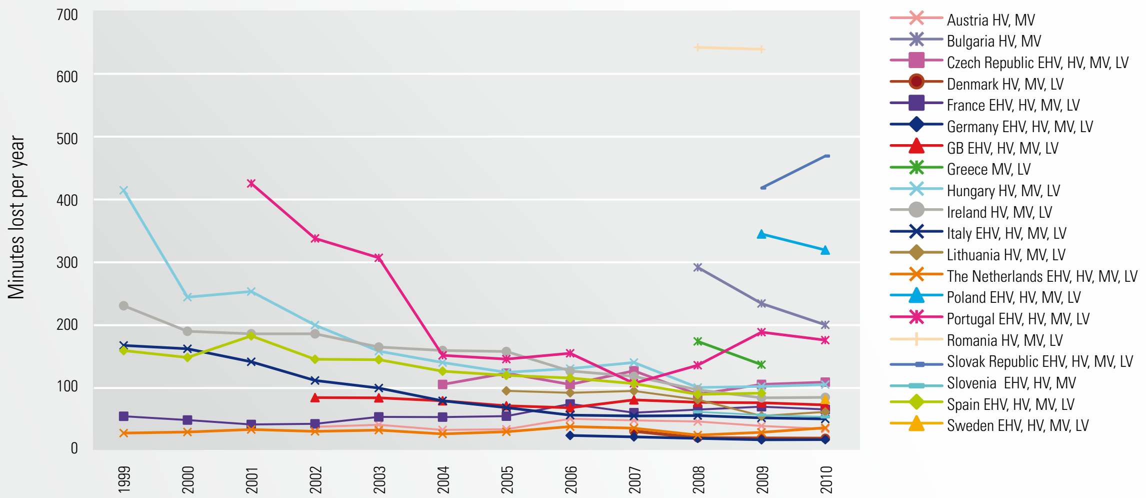
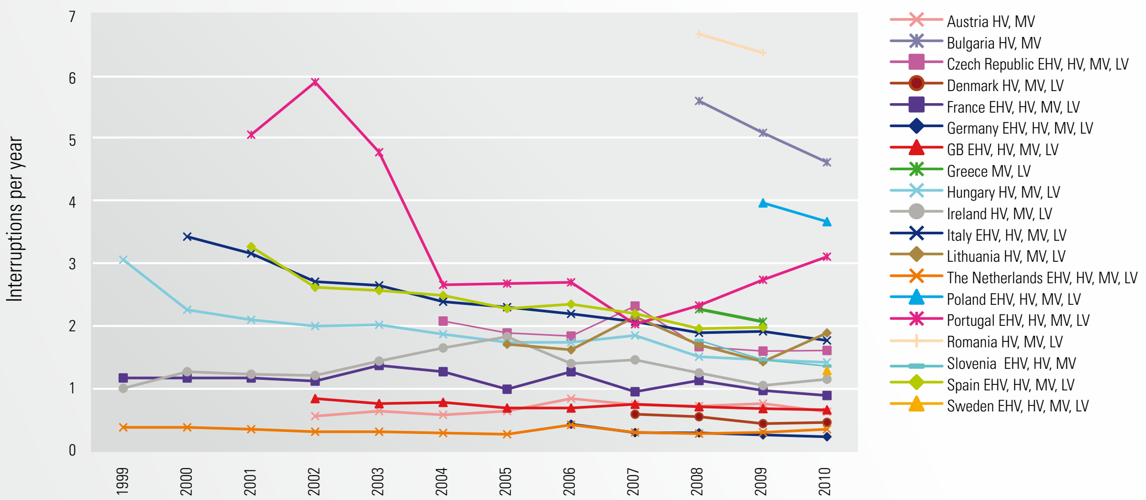


FIGURE 2.2 | Unplanned long interruptions excluding exceptional events; number of interruptions per year (1999 - 2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur[5]



starting from 2012. Poland has measured these values since 2008. Portugal evaluated this indicator in LV and its interruptions not attributable to force majeure. Although Slovenia specified that all voltage levels are monitored, only the MV data is used here due to unavailability of LV data, as well as a different weighting method for calculation of SAIFI on the EHV/HV level. Slovenian data includes the interruptions attributable to "third party" (values 8/8/12 in 2008/2009/2010 related to Figure 2.1 and 0.33/0.33/0.31 in 2008/2009/2010, related to Figure 2.2), as well. "Third party" comprises also the impact of the interruptions that originated outside of the DSO (so at EHV and HV – under supervision of Transmission System Operator (TSO).

5. Portugal changed its 2001 value from 5.09 in the 4th Benchmarking Report to 5.90 in 5th Benchmarking Report

In general, monitoring of unplanned long interruptions in The Netherlands applies to all voltage levels. The NRA only receives information concerning the voltage level that the customers are connected to. The NRA has no information on the location of origin of the unplanned interruption. In Spain, all incidents over 1kV are monitored. They are assigned to customers using their connection with the network. For LV customers below 1kV, the transformation centre is used.

Comparing the performance between different countries must be done carefully as not all countries include incidents at all voltage levels in their statistics. For example, as already illustrated above in the case of Slovenia.

2.6.2. Unplanned long interruptions, all events

Data was also obtained for the continuity of supply indicators including all events, i.e., without removing exceptional events from the statistics. Figure 2.3 shows the minutes lost per year, with unplanned long interruptions including all events. The values show much larger year-to-year variations than the filtered values in Figure 2.1.

Austria reported unplanned ASIDI values and reported the coverage of 81% in 2002; Finland reports T-SAIDI; Denmark monitors only interruptions lasting one minute or longer; the United Kingdom those lasting three minutes or longer. In France, only data from one distributor (covering over 95% of the country) is reported. The blackout on 28 September 2003 and the load shedding on 26 June 2003 (September blackout and June brownout, respectively) caused the high value in the minutes lost in Italy. Norway's data does not include incidents at LV, but LV customers are included. Portugal evaluated LV interruptions not attributable to force majeure. For the reasons reported above, MV data is used in Slovenia. Also as explained in the previous section, in Spain all incidents over 1 kV are monitored. The high values of minutes lost in 2005 and 2007 in Sweden show the impact of two severe storms ("Gudrun" in 2005 and "Per" in 2007).

Extreme weather situations have occured in many European countries over recent years which have influenced the values that have been monitored and reported (Finland 2001, Italy 2003, Portugal 2004, Sweden 2005 and 2007, Estonia 2008). In general, the minutes lost over the 14 countries that contributed data ranges between 50 and 600 minutes per year.

Figure 2.4 shows the number of interruptions per year, with unplanned long interruptions including all events. The year-to-year variation in the number of interruptions is less than the variation for minutes lost: extreme events result in longer interruptions more often than in more interruptions. By way of example, the number of interruptions in 2003 in Italy is about one interruption higher than the value for neighbouring years (because the 28 September 2003 blackout affected almost all of Italy); however, the minutes lost are 450 minutes higher than in neighbouring years. The exception is the year 2001 in Finland, where the number of interruptions is 3.5 interruptions more than in 2000 or 2002 and the minutes lost are about 350 minutes higher than in 2000. Romania reported data for 2008 and 2009, with very high values.

If we remove the values for Portugal before 2004, Finland in 2001 and 2005, Estonia in 2008 and Romania in general, the range of the number of interruptions over the 14 countries that contributed data is between 0.5 and 5 interruptions per year.

Austria monitors unplanned ASIFI values, with coverage of 81% in 2002. Denmark monitors the interruptions lasting one minute or longer, France reported data from one distributor (covering 95% of the network). For Italy's 2003 values, the September blackout and June brownout must be taken into account. Finland reported T-SAIFI values. Again, Slovenia's values include only the MV data.

2.6.3. Short interruptions

As discussed in Section 2.4, about half of the countries make no distinction between long and short interruptions. Additionally, few countries differentiate between interruptions lasting less than one second (or similar values), known as transient interruptions, and those lasting longer than 1 second and less than 3 minutes.

As discussed in Section 2.5, nearly all countries use the indicator for the average number of times per year that the supply to a network user is interrupted for 3 minutes or less (usually called MAIFI).

When calculating MAIFI, the 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. In fact, MAIFIE (Momen-

FIGURE 2.3 | Unplanned long interruptions including all events; minutes lost per year (1999 - 2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur

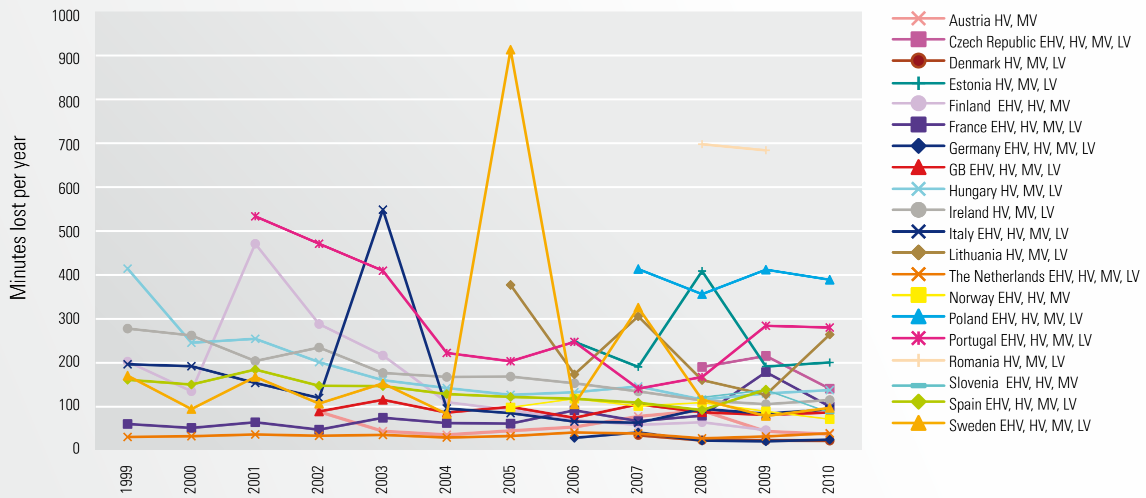
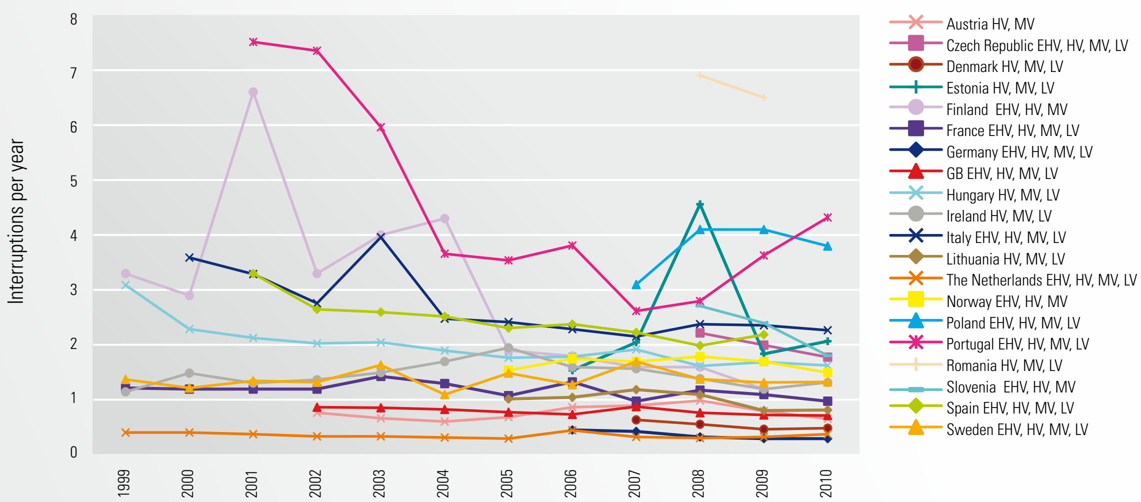


FIGURE 2.4 | Unplanned long interruptions including all events; number of interruptions per year (1999 - 2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur



tary average interruption event frequency index, according to the term used in CENELEC TR 50555) is used in practice in most countries for the average frequency of momentary interruptions. In addition, when calculating MAIFIE, the aggregation rules used for counting short interruption sequences are very important and can greatly affect the calculated values. The comparison between the Italian MAIFIE indicators with two different aggregation rules over the years 2004-2007 in Table 2.9 provides a practical example of the impact of aggregating events.

Table 2.9 reports the data available from 8 countries. The actual data for France, Hungary and Italy do not include transient interruptions, which have a separate definition in such countries.

TABLE 2.9 | Actual data for short interruptions (average number of short interruptions per year, decimals as reported by the responding countries) Note: voltage levels at which interruptions originate: E - EHV; H - HV; M - MV; L - LV

Country/ voltage	Index (aggreg)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FI (EHM)	T-MAIFI	5.3	4.9	5.6	5.2	3.8	NA	8.4	7.3	7.5	6.8	5.0	NA
FR (all)	MAIFIE (60 min)	3.1	2.8	2.3	2.0	2.6	2.6	2.4	2.9	2.4	2.9	2.3	2.2
GB (all)	MAIFIE (see note)				0.754	1.013	1.025	1.033	1.098	1.292	0.859	0.784	0.709
HU (HML)	MAIFIE (see note)					10.38	10.26	8.76	9.09	10.45	10.19	8.81	9.62
IT (all)	MAIFIE (3 min)				6.68	6.43	5.83	5.895	4.769	4.729	NA	NA	NA
IT (all)	MAIFIE (60 min)						4.55	4.18	3.49	3.500	3.608	3.539	2.792
NO (EHM)	SAIFI_ short								1.7	1.8	2.1	1.7	1.3
PL (all)	MAIFI									4.1	4.4	3.3	3.6
SE (all)	MAIFIE (3 min)												1.16

Note: In France, aggregation time is 60 minutes for a short interruption after a long interruption. Aggregation time is 2 minutes for a short interruption before a long interruption and for a short interruption after another short interruption.
In Great Britain, aggregation is 3 hours after a long interruption, 3 minutes after a short interruption.
In Italy, 60 minutes aggregation (either after long or after short) is possible only if same interruption cause and same origin voltage level.
In Hungary, a short interruption after a transient interruption is counted as1 if the automatic reclosing action was successful. Further, a short interruption before a long interruption is counted as 1 short interruption, whereas short interruptions after long or short interruptions are not counted.

2.6.4. Planned (notified) interruptions

Planned duration relates to those minutes off-supply experienced by network users if they were given prior notice that they would be going without supply. The general and national rules related to definition and treatment of this kind of interruption can be found in Section 2.4.2.

The minutes lost per year due to planned interruptions, for the reporting countries, is presented in Figure 2.5. The value shows a very wide spread between the countries, from less than 10 minutes per year to over 400 minutes per year. No trends are visible in the figure; the minutes lost due to planned interruptions remain more or less constant during the observation period, although some countries show a minor reduction.

The differences between states 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 LV in their statistics. Radial networks without redundancy, where planned interruptions are necessary for maintenance, are more common at low-voltage levels. Not including incidents at LV may significantly underestimate the number and duration of planned interruptions. Incidents at LV are not included in the values for Austria, Bulgaria, Finland, Norway and Slovenia.

Regarding planned interruptions, The Netherlands records planned interruptions at all voltage levels, but in practice these only occur in the LV and MV networks. The data that is reported to the NRA makes a distinction between the voltage levels that the customers are connected to (at an aggregated level: LV, MV, HV and EHV). The NRA has no information about the location of the planned interruption.

The number of planned interruptions per year is shown in Figure 2.6. As with minutes lost, the number of interruptions also varies significantly between countries and there is no visible trend; except for Bulgaria, Romania and Slovenia, where the duration of interruptions (for the years reported) is constantly and significantly decreasing.

FIGURE 2.5 | Planned interruptions: minutes lost per year (1999-2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur

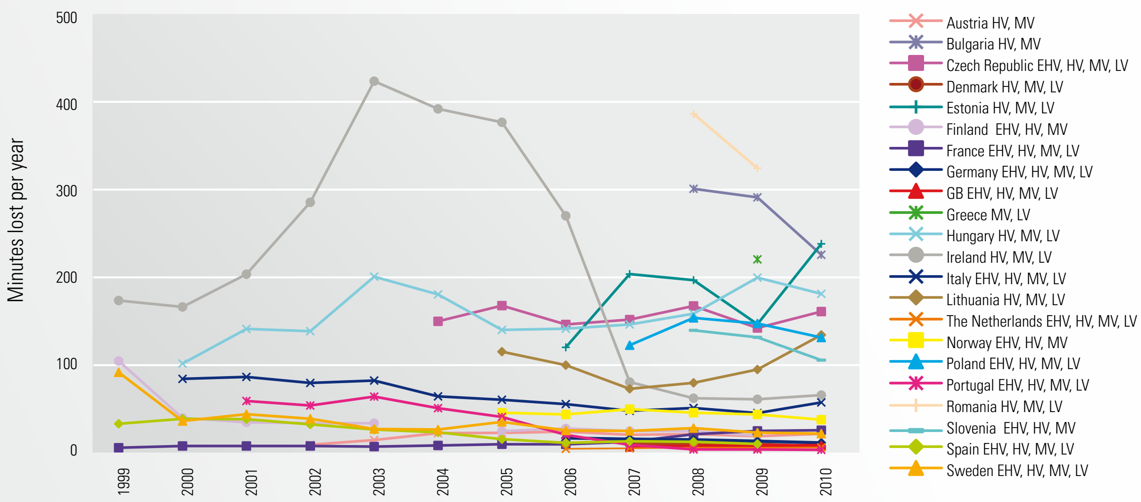
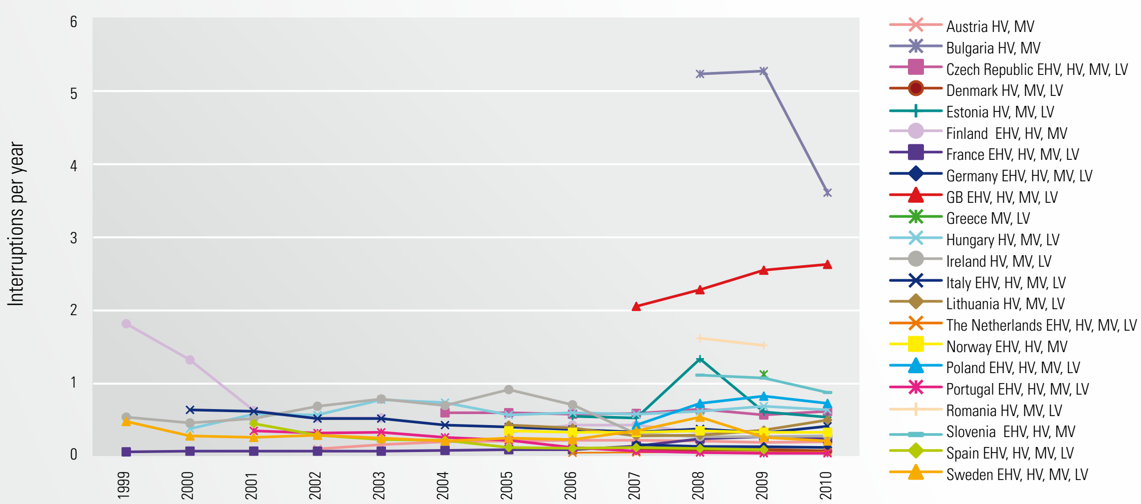


FIGURE 2.6 | Planned interruptions: number of interruptions per year (1999 - 2010). The voltage level (EHV, HV, MV, LV) relates to where the incidents occur



2.6.5. Interruptions on the transmission networks

As discussed in Section 2.5.1, the most common indicators for measuring continuity of supply in transmission networks are ENS and AIT. ENS gives the total amount of energy that would have been supplied to the interrupted users if there had not been any interruption. AIT is expressed in minutes per year and calculated as 60 times the ENS (in MWh) divided by the average power supplied by the system (in MW). CEER's data survey aimed to collect ENS and AIT indices for both long and short interruptions[6]. France clarified that the national indicators are applied only to long interruptions. Table 2.10 reports the ENS data available from 14 countries. Table 2.11 reports the AIT data available from 8 countries.

The definition of the transmission network can significantly affect comparisons. Whereas in most countries the transmission network includes EHV and HV, the transmission network in the Czech Republic (plus special 110 kV lines), Great Britain, Hungary, Norway (plus selected 132 kV lines), Romania, the Slovak Republic, Spain and Sweden mostly corresponds to EHV.

TABLE 2.10 | Actual data for Energy Not Supplied (in MWh) due to interruptions in transmission networks (excluding exceptional events)

	Note	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CZ					290	532	625	71	175	274	121	138	7
FI		419	0	243	63	68	68	90	140	130	90	190	NA
FR		2054	2693	1812	1753	3211	1891	1598	1416	1815	3563	5089	2428
GB				1404	698	415	1329	1119	2015	528	1675	848	672
HU	EHV	19	13	3	1	17	53	39	6	18	3	0	0
IE								0	182	287	60	1	119
IT									3477	8465	1528	2372	2076
LT								12	5	37	2	2	12
NO	EHV	0	0	13	196	966	1284	1466	60	878	915	0	26
PL		2845	3170	2929	2578	2615	2846	28	25	17	572	3	19
PT		273	1984	252	76	142	496	40	263	76	130	43	116
SI	excl. 3rd party					2	95	3	157	34	1	8	68
ES	EHV peninsula	676	779	6990	803	466	1250	549	936	757	574	438	1569
SE	EHV, no EE	96	91	23	49	10417	25	4	96	13	3	5	5

Note: Data from Sweden does not exclude exceptional events (EE)

TABLE 2.11 | Actual data for Average Interruption Time (in minutes per year) due to interruptions in transmission networks (excluding exceptional events)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FI	2.790	0.000	1.550	0.390	0.410	0.410	0.560	0.820	0.730	0.550	1.110	NA
FR	2.900	3.600	2.500	2.400	4.200	2.400	2.000	1.800	2.300	4.400	6.400	2.900
IE			1.130	0.640	0.490	0.360	0.004	2.300	3.400	0.700	0.006	1.400
IT								5.279	12.800	2.310	3.824	3.302
PT	3.220	29.050	3.790	1.070	2.020	6.680	0.520	3.530	0.810	1.350	0.440	1.160
SI					0.100	4.030	0.110	6.330	1.350	0.060	0.360	2.950
ES	1.927	2.107	17.868	2.006	1.095	2.798	1.176	1.939	1.523	1.147	0.910	3.170
SE	0.450	0.420	0.100	0.220	47.517	0.093	0.016	0.357	0.049	0.012	0.021	0.019

Note: Data from Sweden does not exclude exceptional events

6. ENS can be applied to both long and short interruptions in the countries where these interruption types are defined. This is different to the computation of the SAIDI indicator for distribution networks, which normally refers only to long interruptions. The different definition can be associated to the meshed nature of transmission networks, which normally leads to shorter interruption times compared to those of interruptions in radial distribution networks. As a consequence of shorter interruption times, the impact of short interruptions in ENS and AIT indicators tends to be greater than their impact in the SAIDI index.

2.7. Analysis of Continuity by Disaggregated Data

2.7.1. Interruptions in rural and urban networks

Definitions of different types of areas used by different countries are presented in Table 2.12. There are significant differences – for example, in Italy a municipality with more than 50,000 inhabitants represents an urban area, while in France this is considered suburban. In Slovenia, the classification of settlements is based on the standardised methodology defined by the Statistical Office of the Republic of Slovenia: the MV feeder type is considered.

In some countries, a comparison is made between the continuity of supply in rural, suburban and urban networks. Data was available for 5 countries: France, Italy, Portugal, Romania and Slovenia, as shown in Figure 2.7 for the duration of interruptions and in Figure 2.8 for the numbers of interruptions.

TABLE 2.12 | Definitions of urban, suburban and rural areas in use in 5 European countries

Country	Areas	Definitions
FRANCE	Rural	All towns and villages < 10,000 inhabitants
	Urban	Towns with more than 100,000 inhabitants and Paris area
	Suburban	10,000 < towns and suburbs < 100,000 inhabitants
ITALY	Rural	Villages up to 5,000 inhabitants (included)
	Urban	Cities above 50,000 inhabitants
	Suburban	Municipalities above 5,000 inhabitants up to 50,000 inhabitants (included)
PORTUGAL	Rural	Since 2006: Zone C (Rural): locality with less than 2,500 customers
	Urban	Since 2006: Zone A (Urban): main cities and localities with more than 25,000 customers
	Suburban	Since 2006: Zone B (Semi-urban): locality with less than 25,000 and more than 2,500 customers
ROMANIA	Rural	According to administrative-territorial classification
	Urban	According to administrative-territorial classification
	Suburban	-
SLOVENIA	Rural	Type of MV feeder (rural): 2/3 of all connected customers must be located outside the urban settlements. The classification of settlements is based on the standardised methodology defined by Statistical Office of the Republic of Slovenia.
	Urban	Type of MV feeder (urban): 2/3 of all connected customers must be located in urban settlements. The classification of settlements is based on the standardised methodology defined by Statistical Office of the Republic of Slovenia.
	Suburban	Type of MV feeder (mixed): cannot be classified as one of the other two types (urban, rural).

FIGURE 2.7 | Comparison of unplanned interruption values between different areas in 5 countries; minutes lost per year (1999 - 2010). The voltage level (LV, MV, HV) relates to where the incidents occur

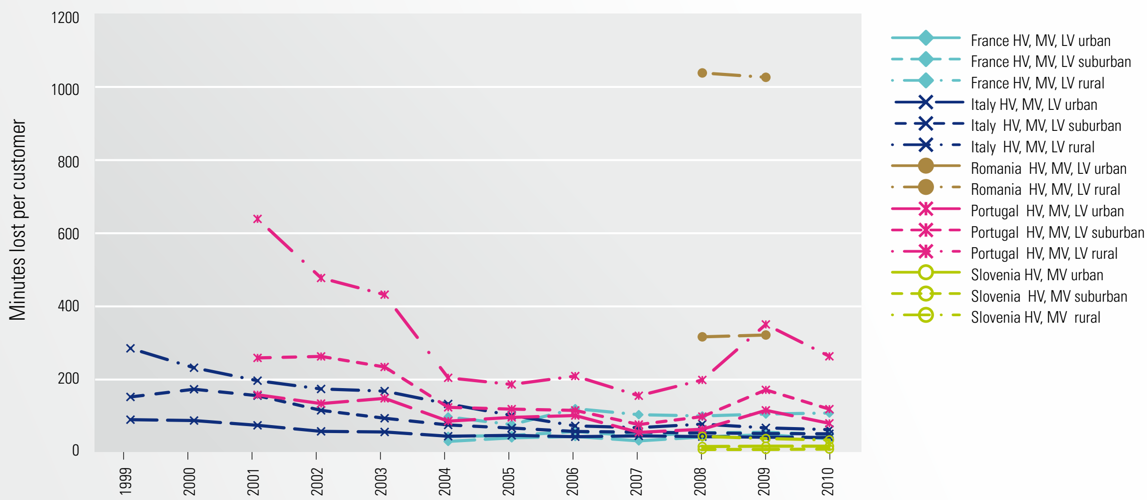
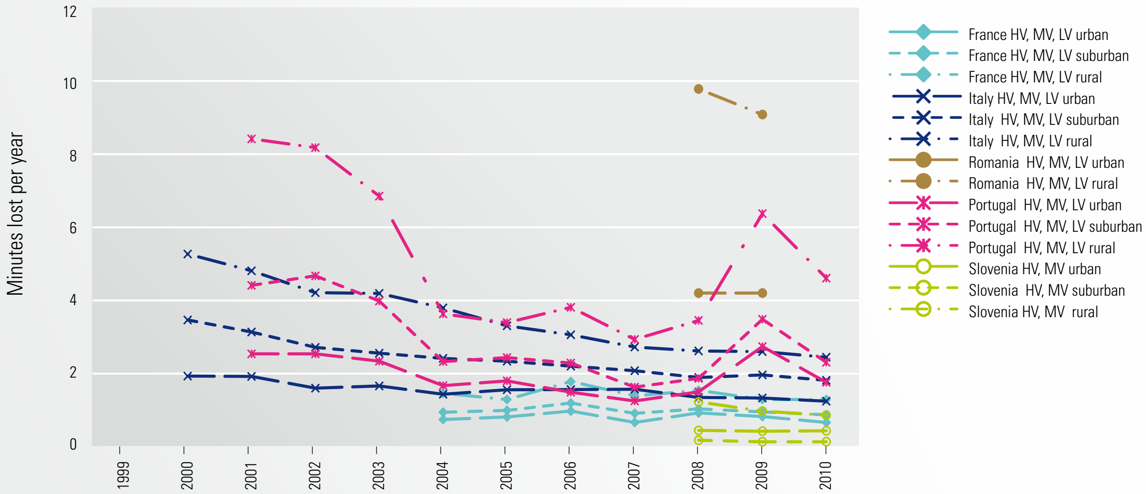


FIGURE 2.8 | Comparison of unplanned interruption values between different areas in 5 countries; number of interruptions per year (1999-2010). The voltage level (LV, MV, HV) relates to where the incidents occur



The overall conclusion is that continuity of supply improves when moving from rural to suburban to urban areas. The values for the minutes lost during this kind of interruption for the three areas are similar in almost all countries and are decreasing constantly.

Improvements in continuity of supply have taken place in nearly all these countries and in all areas. The difference in the number and duration of interruptions between the areas has diminished over the years.

2.7.2. Interruptions originating on different voltage levels

Although few countries have provided reliable data according to the voltage level of the incidents, the data still clearly indicates that around 70% of both SAIDI and SAIFI for LV users are caused by incidents on MV networks, as illustrated in Tables 2.13 and 2.14. The contribution of incidents at LV to SAIDI and SAIFI varies more strongly between countries; as does the contribution of incidents at EHV and HV. However, incidents on LV networks are not automatically registered and their impact is only estimated based on notifications from interrupted users. The contribution of incidents at LV to SAIDI and SAIFI might therefore be underestimated, assuming that some incidents are not notified.

TABLE 2.13 | Average distribution of incidents according to their voltage level, weighted by the number of network users affected and the duration of the interruption, in several European countries

Country	Limit MV-HV	Period analysed	Incidents EHV/HV	Incidents MV	Incidents LV
DENMARK	25 kV	2007-2009	10.2%	75.9%	13.9%
FRANCE	45-63 kV	2005-2010	7.9%	76.8%	15.3%
HUNGARY	35-120 kV	2005-2010	0.8%	69.9%	29.3%
IRELAND	20-38 kV	2005-2008	12.0%	78.9%	9.0%
ITALY	35 kV	2005-2010	4.5%	64.3%	31.2%
THE NETHERLANDS	36 kV	2005-2010	21.5%	61.1%	17.4%
OVERALL AVERAGE			**9.5%**	**71.1%**	**19.4%**

TABLE 2.14 | Contribution to SAIFI according to the voltage level of incidents - Average distribution of incidents according to their voltage level, without exceptional events, weighted by the number of network users affected, in several European countries

Country	Limit MV-HV	Period analysed	Incidents EHV/HV	Incidents MV	Incidents LV
FRANCE	45-63 kV	2005-2010	10.1%	85.2%	4.6%
HUNGARY	35-120 kV	2005-2010	3.1%	81.2%	15.7%
IRELAND	20-38 kV	2005-2010	16.7%	79.4%	3.9%
ITALY	35kV	2005-2010	8.1%	82.7%	9.2%
THE NETHERLANDS	36kV	2005-2010	30.3%	59.4%	10.2%
OVERALL AVERAGE			**13.7%**	**77.6%**	**8.7%**

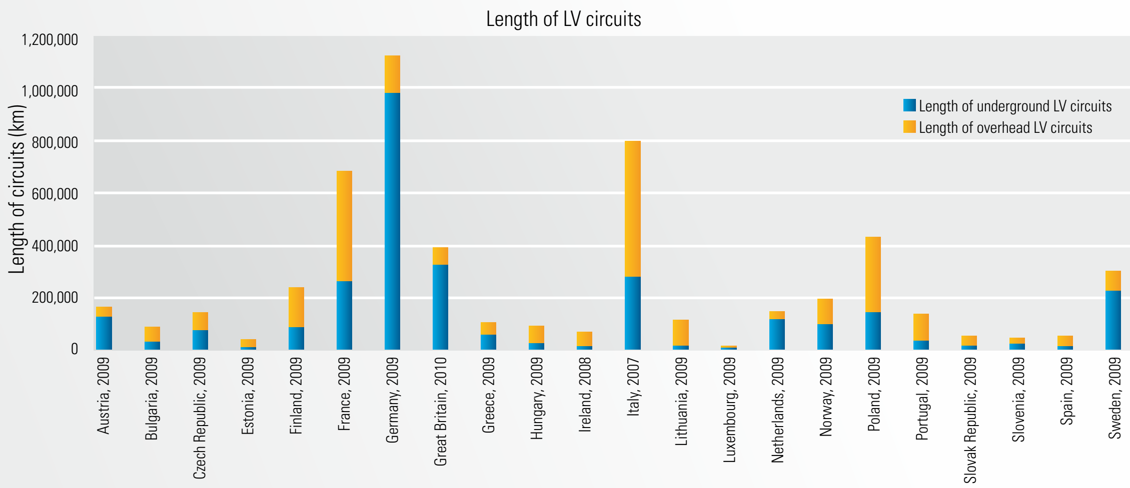
It should be noted that there are slight differences in the definitions of the voltage levels between different European countries. LV networks always correspond to networks below 1 kV[7], while the boundary between MV and HV is located around 35 kV in most countries: from 20 kV to 72.5 kV for the upper MV limit, and from 25 kV to 120 kV for the lower HV limit.

2.7.3. Technical characteristics of electricity networks

The following sections aim to establish whether a correlation exists at European level between the continuity of supply and the technical state of the network. The analysis focuses in particular on the percentage of underground cables in distribution networks, as this is supposed to have a significant impact on the continuity of supply and is easy to quantify.

European networks are designed in various ways, which can be explained by different factors such as the population density, the country's topology, climate and the history behind the construction and the evolution of the electricity networks. There is a large variety of parameters for the definition of the technical state of networks. These may vary widely in the different countries and may have an impact on continuity of supply. As mentioned previously, the present analysis does not aim to be comprehensive and is mainly focused on one important parameter: the percentage of underground cables in networks. Figure 2.9 below and Figure 2.10 and Table 2.15 show the length of cable and overhead line circuits in LV and MV networks in several European countries.

FIGURE 2.9 | Length of cable and overhead line Low Voltage (LV) circuits in European countries



7. 1 kV lines are sometimes also included as LV.

FIGURE 2.10 | Length of cable and overhead line Medium Voltage (MV) circuits in European countries

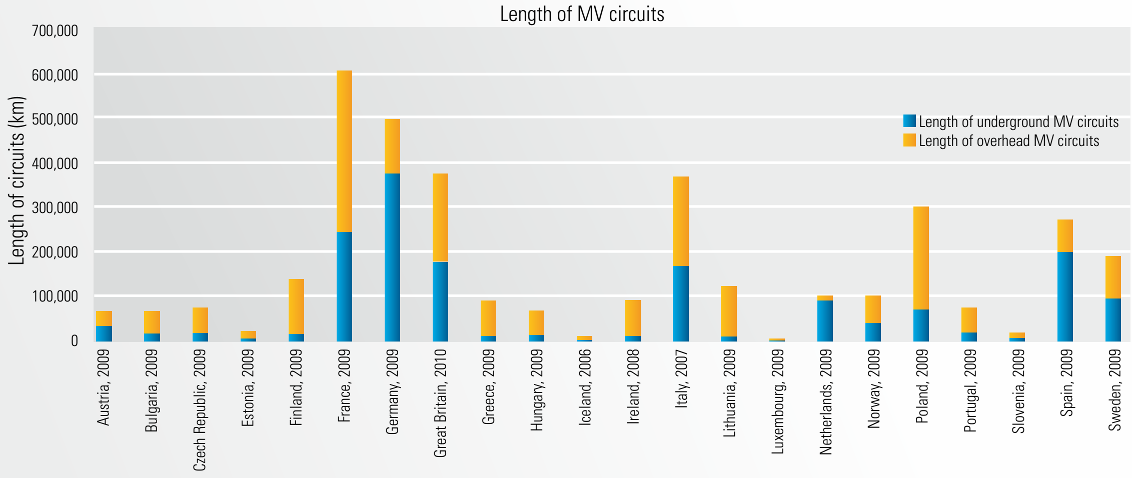


TABLE 2.15 | Length of circuits in European countries

Country, year	Low Voltage				Medium Voltage			
	Length of underground cable LV circuits, km	Length of overhead line LV circuits, km	Total length of LV circuits, km	Percentage of underground cable in LV networks	Length of cable MV circuits, km	Length of overhead line MV circuits, km	Total length of MV circuits, km	Percentage of underground cable in MV networks
Austria, 2009	123,235	40,938	164,173	75.06%	35,338	31,141	66,479	53.16%
Bulgaria, 2009	25,686	62,718	88,404	29.06%	13,816	49,574	63,390	21.80%
Czech Republic, 2009	71,704	69,173	140,877	50.90%	15,899	59,745	75,644	21.02%
Estonia, 2009	7,890	28,914	36,804	21.44%	5,754	21,438	27,192	21.16%
Finland, 2009	82,460	150,933	233,393	35.33%	15,021	121,998	137,019	10.96%
France, 2009	258,109	422,863	680,972	37.90%	243,584	360,602	604,186	40.32%
Germany, 2009	979,961	142,701	1,122,662	87.29%	372,246	124,758	497,004	74.90%
Great Britain, 2010	327,609	64,929	392,538	83.46%	174859	198,556	373,415	46.83%
Greece, 2009	53,489	48,809	102,298	52.29%	8,972	82,116	91,088	9.85%
Hungary, 2009	22,744	63,568	86,312	26.35%	12,438	53,807	66,245	18.78%
Iceland, 2006					3,076	6,142	9,218	33.37%
Ireland, 2008	13,192	55,498	68,690	19.21%	8,571	81,270	89,841	9.54%
Italy, 2007	274,300	520,773	795,073	34.50%	163,008	205,789	368,797	44.20%
Lithuania, 2009	12,477	95,882	108,359	11.51%	9,896	110,940	120,836	8.19%
Luxembourg, 2009	5,301	396	5697	93.05%	2093	1,165	3,258	64.24%
The Netherlands, 2009	112,124	33,824	145948	76.82%	91279	10,119	101,398	90.02%
Norway, 2009	97,227	99,836	197,063	49.34%	37334	60,797	98,131	38.05%
Poland, 2009	137,725	290,360	428,085	32.17%	67565	234,404	301,969	22.37%
Portugal, 2009	31,714	104,225	135,939	23.33%	15113	58,261	73,374	20.60%
Slovak Republic, 2009	11,248	39,833	51,081	22.02%				
Slovenia, 2009	19,396	25,584	44,980	43.12%	4339	12,401	16,740	25.92%
Spain, 2009	10,682	39,605	50,287	21.24%	196674	76048	272,722	72.12%
Sweden, 2009	225,949	76,564	302,513	74.69%	93653	96,627	190,280	49.22%
	Average			**44.94%**	**Average**			**35.77%**

Figure 2.11 below shows a strong statistical correlation between the percentage of underground cables in MV networks and the density of inhabitants in a certain country. The reasons for using underground cables in high density areas are partly practical and aesthetic, but also related to the continuity of supply. In areas with higher density, the costs per user of undergrounding are lower. It can be reasonably assumed that the density is strongly related to the population density. The statistical correlation is slightly lower for LV networks (not shown here).

Some countries have a particularly high percentage of underground cables compared to their low density of inhabitants (for example, Sweden, Iceland and Austria) for which there are several possible explanations. For instance, in northern countries (Finland, Sweden and Norway) and mountainous countries (Austria), the low national average population density hides rather high population densities in certain areas. Also, some specific climate or geographic conditions (for example, uneven ground or sandy soil) may favour underground cables.

2.7.4. Correlation between interruptions and undergrounding - Preliminary remarks

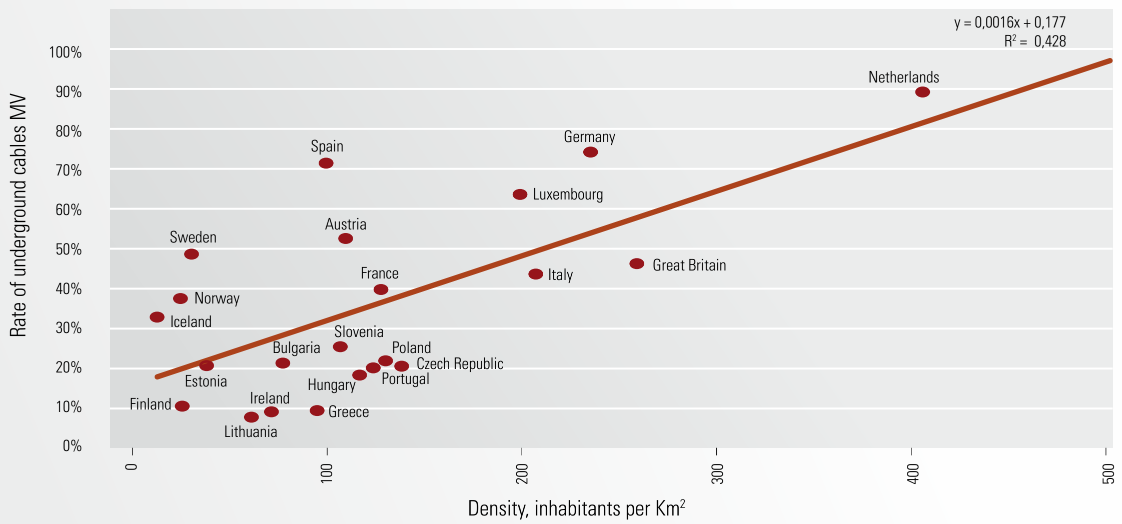
Continuity of supply depends on a variety of parameters that can vary widely from country to country, which makes it difficult to analyse the specific impact of the percentage of undergrounding on the continuity of supply independently from the other parameters. However, it is possible to observe general trends through basic statistical analysis, which can be valuable for confirming and illustrating existing hypotheses.

<u>Many indicators available</u>

A large variety of indicators for continuity of supply is available for analysis:

- SAIDI for unplanned interruptions with exceptional events included;
- SAIDI for unplanned interruptions with exceptional events excluded;
- SAIDI for planned interruptions;
- "total SAIDI" which takes into account planned and unplanned interruptions (exceptional events included);
- SAIFI for unplanned interruptions with exceptional events included;
- SAIFI for unplanned interruptions with exceptional events excluded;
- SAIFI for planned interruptions;
- MAIFI;
- …

FIGURE 2.11 | Statistical correlation between the percentage of underground cables in Medium Voltage (MV) networks and density in European countries



For each indicator, several years of data are available. Especially if exceptional events are included, it might be advisable to use an average over several years instead of the values for one particular year. This would increase the stability of the indicator. Also, as most interruptions are caused by incidents on MV networks, the percentage of underground cables in MV networks should be preferred, even though it appears that the results for both percentages on MV and LV networks do not differ significantly.

CEER's analysis is based mostly on SAIDI since it is available in almost every country and is a good indicator for evaluating the continuity of supply in distribution networks. In most countries, SAIDI takes into account all incidents regardless of the voltage level in which they occur. However, some countries do not take into account incidents in LV networks. In such countries, SAIDI is somewhat underestimated. As Finland and Spain do not calculate SAIDI, it is assumed that T SAIDI in Finland and TIEPI in Spain (both equivalent to ASIDI, weighted by rated power) are valid estimates. However, it is noteworthy that ASIDI is generally lower than SAIDI, considering the actual difference between ASIDI and SAIDI in both Austria and France. SAIFI is also investigated, but to a lesser extent.

<u>Important reservations</u>

Several important reservations must be made regarding the analysis.

Firstly, the present chapter focuses on undergrounding and therefore does not allow comparisons with various other actions that could be beneficial to continuity of supply. These actions include for instance the improvement of the redundancy of the networks and the allocation of more resources to preventive maintenance, such as monitoring of the networks, replacement of old or weak components by more robust ones or trimming of trees.

Moreover, this chapter does not include a cost-benefit analysis of the impact of the percentage of underground cables on the level of continuity of supply. Therefore, no conclusion can be drawn regarding the cost-benefit balance of undergrounding the networks for the sole purpose of improving continuity of supply. Incidentally, if it is generally accepted that undergrounding the networks improves continuity of supply, it is also often accepted that its cost-benefit balance is in general rather low compared to some other possible solutions, as undergrounding is very expensive.

Also, it is important to note that a strong statistical correlation between two indicators does not imply that one is the main cause of the other. In the present case, the many parameters that impact the continuity of supply are correlated to a certain extent. Case study 2 in Annex to chapter 2 on Continuity of supply discusses that in France, the main reason for the high availability of networks in urban areas is not the high percentage of underground cables, even though there is indeed a much higher percentage of underground cables in urban areas than in rural areas. Case study 3 provides an example of how underground cabling relates to SAIDI and population density in Sweden. It is not possible to class any European country as a totally rural or urban area, but it is likely that the population density is positively correlated with most parameters that improve the continuity of supply, including the percentage of underground cables. As a consequence, it is difficult to assess precisely the specific impact of the percentage of underground cables on continuity of supply.

2.7.5. Correlation between interruptions and undergrounding - Results

<u>Similar results regardless of the indicator</u>

The use of linear regression provides rather similar results for most indicators. Even if datasets are too small to give robust results (there are 18 replies), there is still a noticeable trend, which tends to confirm existing statements regarding underground cables:

- underground cables are protected from several very common causes of incident, and therefore have a lower failure rate (number of failures per year) than overhead lines;
- in particular, they are far less prone to widespread failures, mostly caused by storms, than overhead lines;
- they do have several downsides: they are more difficult to repair, sometimes damaged by earthworks and more affected by some specific natural events (for example floods and earthquakes), even though these events are generally rare;
- the downsides are not sufficient to offset the benefits, and continuity of supply benefits from undergrounding.

For most indicators, the linear regression shows that SAIDI decreases by around 1.8 min for each additional percentage point of undergrounding (and SAIFI by around 0.02); the correlation coefficient r^2 ranges from 0.2 to 0.4 (often around 0.3), which is rather low. However, when three or four extreme values are removed from datasets, then correlation coefficients r^2 are much better and often reach 0.5.

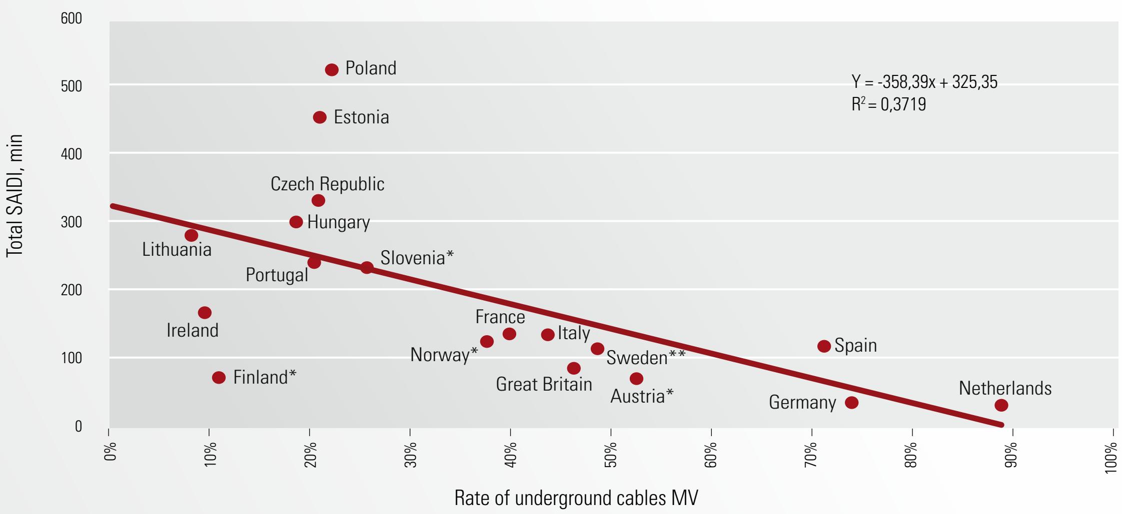
Several trends that were expected based on "on-site observations" are not significant in the present datasets. In particular, underground cables generally experience few incidents but require a lot of time to be repaired. The positive effect of undergrounding on SAIFI is therefore expected to be higher than the benefits on SAIDI. But no such trend is observable in the present datasets. Similar observations can be made regarding exceptional events. Most exceptional events are actually storms, which do not significantly impact underground cables. The benefits of undergrounding on SAIDI are therefore expected to be higher when exceptional events are taken into account. This trend is merely slightly noticeable in the present datasets.

Illustration: "total SAIDI" averaged over three years

Figure 2.12 below, illustrates this trend, based on one specific indicator. The indicator used corresponds to "total SAIDI" (unplanned SAIDI including exceptional events plus planned SAIDI), averaged over the three most recent years available (often 2008-2010 or 2007-2009). The percentage of underground cables in MV networks in 2009 is used when available (otherwise it is 2008 or 2007). This choice seemed rather "natural": "total SAIDI" in order to take every interruption into account, underground percentage on MV networks as most interruptions are caused by incidents on MV networks, and averaged over 3 years in order to attenuate the annual variability.

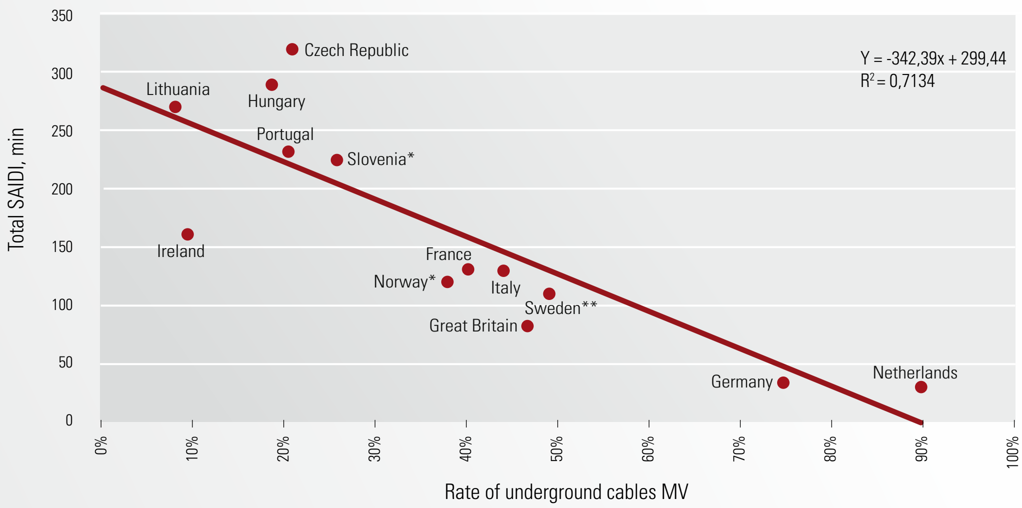
The Figure 2.13 corresponds to the same dataset, but five countries have been removed either because of their extreme SAIDI (Estonia and Poland), or because they use ASIDI instead of SAIDI (Austria, Finland and Spain).

FIGURE 2.12 | Statistical correlation between the percentage of underground cables in MV networks and "total SAIDI" (unplanned SAIDI including exceptional events plus planned SAIDI) averaged over 3 years, in Europe



*As mentioned previously, 4 countries (Austria, Finland, Norway and Slovenia) do not take into account incidents on LV networks and therefore underestimate SAIDI.
**SAIDI in Sweden has been very variable these past years: SAIDI is usually around 100 min, except for 2005 (946 min) and 2007 (345 min) due to large storms.

FIGURE 2.13 | Statistical correlation between the percentage of underground cables in MV networks and "total SAIDI" (unplanned SAIDI including exceptional events plus planned SAIDI), averaged over 3 years, without Austria,Estonia, Finland, Poland and Spain.



*As mentioned previously, two countries (Norway and Slovenia) do not take into account incidents on LV networks and therefore underestimate SAIDI
**SAIDI in Sweden has been very variable these past years: SAIDI is usually around 100 min, except for 2005 (946 min) and 2007 (345 min) due to large storms.

2.8. Standards and Incentives in Continuity of Supply Regulation

2.8.1. Introduction

This section provides an overview of the existing quality regulation frameworks in CEER countries, for electricity distribution as well as for transmission networks. The first review of existing quality incentives and standards was carried out in the 2005 in the 3rd Benchmarking Report. This section provides an update with respect to developments since 2005. In order to assess the developments, the structure of this section is comparable to that of chapter 2 in the 3rd Benchmarking Report. In line with that report, this section focuses on continuity of supply, to which most financial incentives are associated (for economic penalties and compensations in the field of commercial quality, see chapter 4).

As outlined in the 3rd Benchmarking Report, performance-based regulation comprises the following main aspects:

- **Continuity measurement** – a prerequisite for setting standards and reward/penalty regimes. Here, robust and reliable data is needed in terms of the actual continuity levels as well as the level perceived by the network users.
- **Maintenance and improvement of general continuity levels** – the investment decisions of network operators influence current and future quality levels. Depending on the actual quality level, the regulator must make sure that the current status is either maintained in case of existing high continuity levels or improved if the level is low. Preferred regulatory actions to reach these goals include publishing continuity data and the implementation of reward/penalty schemes. Regulatory approaches for general continuity levels are addressed in Section 2.8.3.
- **Continuity ensured for each network user** – the focus is placed on the individual users (especially on the worst-served ones). Minimum standards for quality levels accompanied by associated payments will guarantee that single users will be compensated if the standard is not met by the network operator. The adequacy of the amount of the compensation is usually linked to consumers' perception of quality issues. Cost-estimation surveys addressing customers' willingness to pay or willingness to accept principles provide the basis for such compensation mechanisms. Regulatory approaches on individual continuity levels are discussed in Section 2.8.4.

Most importantly, this section places a special focus on general experiences and those implementation processes as well as possible future improvements of the systems in place. This might be of great assistance for NRAs that plan to introduce (or review) a quality regulation regime in the future.

2.8.2. Measurement of quality levels: a prerequisite for quality regulation

The measurement of actual continuity levels through indicators and standards constitutes the basis for regulating continuity and quality of supply as a whole. In general, the actual measurement of continuity can be performed on two different levels, namely system level and user-specific level. While the measurement at system level is usually done on an aggregate basis, measurement at user level is usually based on surveys asking customers about their satisfaction, expectations, willingness to pay for high quality or willingness to accept low quality levels. As is to be expected, private households and business or industrial consumers can have diverging interests and therefore they will probably also have diverging views regarding the required quality of electricity supply. The implementation of adequate measurement systems is essential for setting standards and incentives at both measurement levels.

The most common indicators for measuring duration and frequency of continuity of supply are SAIDI and SAIFI for distribution networks and ENS and AIT for transmission networks. The measurement of interruptions should cover all network levels. Please refer to Sections 2.4-2.6 for further details regarding the use of indicators and measurement.

As mentioned in Section 2.2, CEER addressed this topic in 2010 in its "Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances", including a consultancy review of many studies in European countries and elsewhere. Moreover, the performance indicator on the 'measured satisfaction of grid users for the "grid" services they receive' is included in the list of potential output measures for future networks. The CEER Smart Grids Status Review (2011) [7] reports national examples of implementation of these measures.

2.8.3. Regulation at system level and reward / penalty regimes

The following section provides an overview of the existing quality incentive schemes in various CEER countries. It also illustrates which indicators and standards are used in this regard. In addition, the economic effects and outcomes of the regulatory actions are addressed. General reward or penalty schemes or incentives to optimise continuity of supply levels have been introduced in 15 of the 26 countries that provided feedback: Bulgaria, Denmark, Finland, France, Great Britain, Hungary, Ireland, Italy, Lithuania, The Netherlands, Norway, Portugal, Slovenia, Spain and Sweden. However, the use of rewards, penalties and a combination of those differs among countries and is also applied differently to the transmission and the distribution levels. Penalties are usually coupled with rewards and are mostly applied to distribution networks. No country relies exclusively on rewarding companies for the improvement of continuity of supply levels. Table 2.16 reveals that countries do not use on the same indicators. Lithuania has a continuity of supply scheme in place, but a detailed description of the incentives was not available. Most of the countries which have not yet implemented a continuity of supply scheme have plans or the intention to introduce such a regime (i.e. Austria, the Czech Republic, Germany, Greece, Luxembourg and Romania). Of these countries, Germany has plans to apply a scheme starting at the beginning of 2012 (see Section 2.8.6. for further details).

Quality as a regulatory element has been implemented in several regimes across Europe, with incentive schemes being the most common ones. The main intention is to keep quality levels at a socio-economically acceptable level and therefore maintaining or improving the existing levels might be on the regulator's radar. Nevertheless, the input-output relationship has to be considered – if the quality level is already very high, then a further improvement might be very costly for the consumer. Existing schemes in 15 countries are reviewed below. The analysis focuses on transmission and distribution networks separately.

Bulgaria uses a combination of penalties and incentives for continuity regulation for distribution companies (no existing scheme for the transmission level) on the basis of SAIFI and SAIDI indicators. Each year, the level of the indicators is determined according to a standardised calculation method

TABLE 2.16 | Continuity of supply regulation at system-level

	Rewards	Penalties	Combination	Continuity indicators used
Distribution	-	DK, HU, IT	BG, FI, FR, GB, IE, IT, LT, NL, NO, PT, SI, SE, ES	BG (SAIFI, SAIDI); FI (outage costs on basis of planned and unplanned long and short term interruptions); FR (SAIDI); GB (customer interruptions and customer minutes lost); HU (SAIDI, SAIFI, outage rate); IE (customer minutes lost, customer interruptions); IT (for the main scheme: SAIDI and SAIFI+MAIFI); NO (interrupted power – planned, unplanned, reference time, duration, time of occurrence); PT (END); SI (SAIFI, SAIDI); SE (SAIFI and SAIDI for DSOs and ENS and interrupted power for regional networks); ES (TIEPI, NIEPI); NL (CAIDI, SAIFI).
Transmission	ES	DK, HU, IT	FI, FR, GB, IE, IT, LT, NO, PT	FI (outage costs on basis of planned and unplanned long term interruptions); FR (AIT); GB (ENS for England & Wales / number interruptions for Scotland); HU (AIT); IE (System Minutes lost); IT (for the main scheme: ENS from 2012; ENS and SAIFI+MAIFI and number affected users till 2011); NO (interrupted power – planned, unplanned, reference time, duration, time of occurrence); PT (TCD – combined average availability rate, in %); SE (ENS and interrupted power).
No existing CoS scheme	AT, CY, CZ, EE, DE, GR, LV, LU, PL, RO, SK			
Intention/plans for implementation	AT (details under consideration), CZ (incentive regime on the basis of reward and penalty schemes with SAIFI and SAIDI indicators), DE (reward and penalty scheme implemented in 2012), GR (penalty and reward scheme on basis of SAIFI and SAIDI indicators), LU (quality incentives under consideration), RO (implementation under consideration).			

which is the same for the whole country. Calculated company values are then compared to determined target indicators. The scheme requires a minimum improvement which is calculated according to the following formula:

$$K = \frac{(RV - TV)}{TV}$$

The correction ratio for the performance of the indicators (K) is determined as the ratio of the difference between the reached value for the reference year (RV) and the target value (TV) divided by the respective target value. A maximum value is determined for each company based on a comparative analysis of EU countries' practices for reached indicators in similar energy companies. Moreover, the regulator takes into account the realised investments of the relevant companies. The continuity scheme is linked to the revenue-cap formula and the incentive is funded by all customers.

Denmark does not distinguish between the transmission and distribution levels and uses a regime which focuses exclusively on penalties. An individual threshold (IT) value for each network company is calculated. If the interruption frequency or duration is higher than the IT, the company is fined. The penalty is graduated up to a predefined cap of 10 percent which equals a penalty of 1 percent of the susceptible costs. The company can be penalised for both the frequency and duration. The maximum penalty is 2 percent of the susceptible costs. In addition, there is a cap of 1 percent to prevent overly high penalties.

The scheme in **Finland** is based on a combination of rewards and penalties which provide incentives to optimise the continuity of supply levels on the transmission as well as on the distribution level. This scheme is funded by all customers. The indicators used are planned and unplanned long term interruptions for transmission companies and planned and unplanned long and short term interruptions for distribution networks. Corresponding outage costs are taken into account. The actual continuity of supply level of each network operator (TSOs and DSOs), which is calculated from historical values, is compared to a set reference level. If the actual level is better than the reference, the network operator will get a lower adjustment of the profit (reward); otherwise it will be penalised. However, the incentive scheme has a dead band in which the economic effect is set to zero. Moreover, there is a symmetric structure of maximum levels (cap and floor) set for penalties and rewards.

As in many other countries, **France** uses a combination of rewards and penalties for both distribution and transmission network continuity regulation. While AIT is the continuity indicator used for the transmission level, SAIDI is addressed at distribution level. Planned interruptions and exceptional events are excluded. The expected level of continuity is estimated in line with the investment programme of the distribution and transmission companies and past values of indicators considered in the incentive scheme. No difference is made between rural and urban areas. While the incentive scheme does not require a minimum improvement of continuity at TSO level, it is required for distribution companies. For the transmission company, the expected level of continuity, i.e. the level that corresponds to no penalty and no reward, is set at 2.4 minutes for the period between 2009 and 2012. For distribution companies, the expected level of continuity is set at 55 minutes for 2009 and 2010, 54 minutes for 2011 and 52 minutes for 2012. No tolerance/dead band is implemented for either the DSO or TSO level. The incentive rate for TSOs and DSOs is calculated according to formulas 1 and 2 respectively:

$$(1)\quad I_N = -9{,}6 \times AIT_{ref} \times 1n\left(\frac{AIT_N}{AIT_{ref}}\right)$$

$$(2)\quad I_N = -4 \times (SAIDI_{N\,ref} - 28) \times 1n\left(\frac{SAIDI_N - 28}{SAIDI_{N\,ref} - 28}\right)$$

Where

I_N is the incentive of the year N (reward if positive; penalty if negative);

AIT_N is the system average interruption time for the year N (excluding planned interruptions and exceptional events);

AIT_{ref} is the reference system average interruption time set at 2.4 minutes until 2012;

$SAIDI_N$ is the system average interruption duration index for the year N (excluding planned interruptions and exceptional events); and

$SAIDI_{N\,ref}$ is the reference system average interruption duration index for the year N set at 55 minutes for 2009 and 2010, 54 minutes for 2011 and 52 minutes for 2012.

Moreover, the incentive of 9.6 M€/minute corresponds to the value of lost load of about 12 €/kWh. Both penalties and rewards are capped at 20 M€ (about 0.5% of the TSO's annual revenue). The incentive of 4 M€/minute corresponds to a value of loss load of about 6 €/kWh. The cap for both penalties and rewards is set at 50 M€ (about 0.5% of the DSO's annual revenue). The incentive is paid through grid tariffs and the higher the performance of the companies, the higher the grid tariff paid by the customers (up to the cap).

Incentive rates in **Great Britain** are used to reward or penalise distribution companies based on their performance regarding continuity standards. The continuity indicators considered in the incentive scheme are customer interruptions (CI) and customer minutes lost (CML), but the exceptional events are excluded. Companies have to reach targets set during the price control process. Each distribution network operator's (DNO) performance provides their resulting penalty or reward, with a limit to the penalty of 1.39% of Return on Regulatory Equity. The system does not have a tolerance or dead band and to challenge the companies, improved performance targets are set for the interruptions scheme. According to the performance of the DNOs, all customers pay or are rewarded through the use of system charges. However, reward and penalty payments do have a lag of two years. The principal formulas used for the purpose of deriving the amount of the total quality of service incentive for each regulatory year are very complex and are calculated differently in relation to different periods of time. Principal Formula 1 calculates the incentive for the Regulatory Years beginning on 1 April 2010 and 1 April 2011 and is as follows:

$$IQ_t = [Q_{t-2}] \times [(1+\frac{I_t}{100}) \times (1+\frac{I_{t-1}}{100})] + QF_t + QG_t + QH_t$$

Where:

IQ_t = the quality of service incentive;

Q_{t-2} = the adjustment to Combined Allowed Distribution Network Revenue to reflect the licensee's performance in each of the Regulatory Years beginning on 1 April 2008 and 1 April 2009;

I_t= the Average Specified Rate in Regulatory Year t;

QF_t= the adjustment to Combined Allowed Distribution Network Revenue with respect to the licensee's performance in Regulatory Year t in relation to the target number of Customers interrupted per 100 Customers in that year;

QG_t= the adjustment to Combined Allowed Distribution Network Revenue with respect to the standard of performance for supply restoration imposed on the licensee; and

QH_t= the adjustment to Combined Allowed Distribution Network Revenue with respect to the standard of performance for supply restoration imposed on the licensee.

Principal Formula 2 calculates the incentive for the Regulatory Years beginning on 1 April 2012 and 1 April 2013 and is this:

$$IQ_t=[QA_{t-2}+QB_{t-2}+QD_{t-2}+QE_{t-2}]\times[(1+\frac{I_t}{100})\times(1+\frac{I_{t-1}}{100})]+QF_t+QG_t+QH_t$$

Where:
QA_{t-2}= the adjustment to Combined Allowed Distribution Network Revenue with respect to the licensee's performance in Regulatory Year t-2 in relation to the target number of Customers interrupted per 100 Customers in that year;
QB_{t-2}= the adjustment to Combined Allowed Distribution Network Revenue with respect to the licensee's performance in Regulatory Year t-2 in relation to the target for the duration of Customer interruptions in that year,
QD_{t-2}= the adjustment to Combined Allowed Distribution Network Revenue with respect to the licensee's overall surveyed performance in Regulatory Year t-2 in relation to target speed and quality of telephone response in that year; and
QE_{t-2}= such positive adjustment (if any) to Combined Allowed Distribution Network Revenue for the Regulatory Year t-2 as may be determined by the Authority in respect of its Customer Service Reward Scheme for best practice in relation to Priority Customers, public communication, and corporate social responsibility.

All other parameters are defined as above in principal formula 1. The total quality of service incentive for the Regulatory Year beginning on 1 April 2014 is calculated according to Principal Formula 3:

$$IQ_t=[QA_{t-2}+QB_{t-2}+QC_{t-2}+QE_{t-2}]\times[(1+\frac{I_t}{100})\times(1+\frac{I_{t-1}}{100})]+QF_t+QG_t+QH_t$$

Where:
QC_{t-2}= the adjustment to Combined Allowed Distribution Network Revenue with respect to the licensee's performance on the broad measure of community satisfaction incentive in the Regulatory Year t (where "community" means the general body of persons, including but not limited to customers who are affected by the licensee's operations) and all other parameters as stated by formulas 1 and 2.[8]

Great Britain adopts a reliability incentive scheme for the transmission network. The transmission owners are incentivised to maintain a reliable system. Each of the licensees is set a target for reliability, and is rewarded for beating this target and penalised if they under-perform. The target is in the form of a range, and if their performance is within this range they are neither penalised nor rewarded. National Grid's reliability is measured by the amount of un-served energy (MWh), whilst SP and Scottish Hydro Electric Transmission Limited (SHETL's) reliability is determined by the number of outages experienced on their system. The rewards and penalties are capped for the licensees a % of their total revenue for the year. The Table below details the parameters of the reliability incentives.

The continuity regulation system in **Hungary** is based on penalties for transmission as well as distribution companies. For the transmission level, the outage rate (the availability of energy, which is the ratio of ENS to available energy) and the unavailability indicator for transmission lines (which is called unavailability indicator of transmission lines) are used as the availability indicators of the network. In addition to the outage rate, SAIDI and SAIFI indicators are considered for distribution companies.

The expected continuity level is calculated on a historical basis for each company whereby the NRA sets a minimum quality requirement with a 5% dead band on the indicators mentioned above. While the individual requirements for improvement of continuity levels are determined for each DSO, the TSOs do not have to achieve minimum levels of improvement. Penalties are limited and depend on the actual performance level and the standard (which was not fulfilled). DSOs have to pay 1-2% of the amount of network charges to customers. The actual performance of continuity standards is considered in the next year's price cap calculation.

In **Ireland**, the continuity scheme is based on a combination of rewards and penalties and is comparable for transmission and distribution companies. There is a single transmission and a single distribution company operating in the region. While the indicator used for the TSO is the system minutes lost, the indicators on the DSO level are the customer minutes lost (SAIDI) and the number of customer

	NGET, National Grid Electricity Transmission plc	SPTL, SP Transmission Limited	SHETL Scottish Hydro Electric Transmission Limited
Upper target	263MWh	10	12
Lower target	237MWh	8	10
Upper Collar	619MWh	22	27
Maximum reward (% of revenue)	1%	0.50%	0.50%
Minimum reward (% of revenue)	1.50%	0.75%	0.75%

8. For further details regarding the calculation of the parameters used in Principal Formulas 1, 2 and 3, please see Section CRC 8 of the Special Licence Conditions issued by Ofgem.

interruptions (SAIFI). For the TSO, the NRA sets an incentive target for a two year period. Considering that system minutes lost (SML) values have varied significantly in the past years, a 'dead-band' is applied to the incentive where no payment or penalty will accrue. The TSO gains a revenue incentive if it manages to bring SML under a certain point set by the NRA. If SML is above the point set by the NRA, the TSO pays a penalty. The targets for the SML incentive are set through reviewing SML results and discussing the expected SML results for the forthcoming year with the TSO. Thus, the incentive scheme does not require a minimum improvement. The level of the reward depends on the amount by which the TSO has beaten the target. Each percentage point of over/under achievement is rewarded by a fixed amount on a symmetrical basis for both rewards and penalties (no use of a dead-band). The most recent incentive period (2009/2010) had a central target of 3.5 SML with an upper maximal value of 5.5 SML and a lower bound of 1.5 SML.

As part of the first two revenue controls for the distribution level, covering the period between 2001 and 2010, financial incentives were used to reduce the annual average number of minutes for which each customer's electricity supply was interrupted (see http://www.cer.ie for further details). There was a financial reward/penalty associated with exceeding/failing the set target values (planned and unplanned interruptions) for each year. While there has been an improvement in performance over the period, leading to payments in 2007 and 2008, (the first year of the control period 2006 to 2010) the DSO did not meet its targets in 2006 and was penalised accordingly. A similar mechanism as the one in the previous control periods has been included for the revenue control 2011 to 2015. The mechanism foresees that both the number of CI and the CML are reduced over time. The level of the reward/penalty depends on the amount by which the DSO has beaten/missed the target. Each percentage point over/under achievement is rewarded by a fixed amount. The annual payment/penalty for CI is limited to 1.5% of total annual DSO revenue. This limit is set at a level to ensure the payment is sufficient to incentivise the DSO while also ensuring the reward/penalty is not overly onerous on either the DSO or its customers. The continuity scheme is linked to the revenue cap mechanism for the transmission and distribution business. The annual payments and penalties are calculated each year and added or deducted from the annual revenues the companies can collect from their customers.

In **Italy**, there are several incentives schemes for distribution and for transmission. Several indicators are adopted accordingly. Two main schemes for distribution, with rewards and penalties, relate to SAIDI and to the sum of SAIFI and MAIFI. The first one (SAIDI-based) has been in place since 2000. The second one (on SAIFI + MAIFI) has been enforced since 2008. Planned interruptions and force majeure events are excluded.

Such schemes refer to past continuity performance and aim towards a 12-year convergence of common targets for continuity levels across 350 territories in Italy (which are differentiated as urban, suburban, rural areas). This implies a requirement to improve for the territories with bad continuity and a requirement to maintain for those ones with good continuity, e.g. the long term target is 25 minutes for urban territories, 40 minutes for suburban territories and 60 minutes for rural territories.

Actual levels are based on a two year rolling average. The slope of the rewards and penalties is symmetrical. Further details on the use of customer surveys on cost of interruptions in order to set the slope are available in the CEER GGP on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances. The mean figures of the Value of Lost Load (for the SAIDI-based scheme) are set at 10,800 €/MWh not supplied for LV domestic users and at 21,600 €/MWh for other users. A joint cap of rewards, a joint floor of penalties and dead-bands are used in the schemes.

Next, a penalty-only scheme for distribution is attached to the number of interruptions for each MV user during a year. The scheme applies for SAIFI in the period 2006-2011 and for the sum of SAIFI and MAIFI from 2012 on. It applies partly as a system-level penalty and partly as individual compensation for MV users (see Section 2.8.4).

Last, a penalty-only scheme for distribution depends on the number of LV users affected by a single interruption lasting more than 8 hours. It has been in force since 2008. The number of LV users with long interruptions is multiplied by 70€ per user in order to determine the annual penalty.

The main (reward/penalty) scheme adopted in **Italy** for the transmission network reliability from 2008 until 2011 is based on actual measurements of three indicators: the first is similar to ENS, the second is the number of interruptions per transmission network user, and the third is the number of NTG users with zero interruptions/year. The economic effect of the scheme is proportional to the performance improvement in the actual levels of the indicators with respect to yearly objectives pre-defined for the whole period on the basis of historical values. From 2012, the scheme is being modified by using only the regulated energy not supplied (R-ENS). The term 'regulated' refers to the limitation function which was adopted in order to deal both with Transmission Major Incidents, by smoothing their effect. Taking into account the different choice of indicators and the end of the first regulatory period, the Value of Lost Load is expected to increase up to 40,000 €/MWh (whereas the value in the years 2008-2011 was 15,000 €/MWh). The main transmission scheme excludes interruptions due to:

- the automatic intervention of under-frequency load shedding schemes as a consequence of disturbances originating in neighbouring interconnected countries;
- preventive load shedding (communicated at least one day in advance adopting defined procedures) as a consequence of expected lack of generation adequacy;
- forced line outages due to public orders (e.g. in case of fire when switching off the HV circuits if demanded by police or fire corps);
- extreme disaster situations (e.g. earthquakes);
- intentional damages (e.g. terrorist attacks).

Next, a penalty-only scheme for transmission depends on ENS to the transmission user due to single interruptions lasting more than 2 hours. It is in force since 2008. The portion of ENS (after two hours) is multiplied by 10,000 €/MWh in order to determine the annual penalty.

Lastly, since 2008 the Italian TSO has to contribute to the distribution penalty-only schemes as a proportion to its own responsibility. This applies for the very long interruptions and for the number of interruptions per year per MV network users. If a MV user is affected by five interruptions with four interruptions originating at the distribution operator and one at the transmission operator, economic compensation is provided 80% by the DSO, 20% by the TSO.

In **Lithuania**, rewards or penalties are linked to a price cap formula via a quality factor and are adjusted every three years. Thus, the incentive is funded by all customers via network tariffs.

While in **The Netherlands** there is no quality regulation implemented on the transmission level, the distribution level has a scheme based on the combination of rewards and penalties. Each DSO is compared to the average value of the quality level of supply and receives a reward or penalty depending on whether it performed better or worse than the average. The average continuity level achieved by all DSOs is used as a standard for the quality factor. Thus, the incentives are equal to the difference between the actual performance level (the value of the quality level of the DSO) and the standard (the average value of the quality level of all DSOs). The scheme does not require a minimum improvement and no distinction is made between urban and rural areas. The valuation of the quality level of supply is based on a cost estimation survey and based on the SAIFI and Customer Average Interruption Duration Index (CAIDI) indicators. The reward or penalty is an incentive to each DSO to deliver the optimal level of continuity of supply. The incentive scheme is based on a formula set by law:

$$TI_t = \left(1 + \frac{(CPI_t - X + Q)}{100}\right) * TI_{t-1}$$

Where:
TI = total income of the DSO in a particular year t;
CPI_t = the consumer price index in year t;
Q = the quality factor; and
X = the efficiency factor.

Thus, the continuity incentive is part of the formula which determines the total income of a DSO. The total income of a DSO is then used to set the prices (price-cap regulation). The continuity-incentive scheme is linked to the price control formula (since the efficiency factor and the quality factor are both in the same formula) to determine the total income of the DSOs. The efficiency factor is derived by considering the average costs of all DSOs as efficient and the quality factor is derived by considering the average value of quality as the standard. Thus, each DSO has to balance efficiency and quality in such a way that the optimal level for both will be reached. If a DSO performs better than average, all of its customers pay a somewhat higher tariff. If a DSO performs worse than average, all of its customers pay a somewhat lower tariff. The total reward or penalty of the Q factor is maximised at 5% of the total income of the DSO but this cap or floor has not been reached yet.

The **Norwegian** quality of supply regulation has been developed gradually since the Energy Act entered into force in 1991. Mandatory monitoring and reporting of long interruptions (> 3 min) started in 1995, while the monitoring of standardisation of the estimation of ENS started in 2000. This laid the foundation for introducing quality dependent revenue caps and the cost of energy not supplied (CENS) arrangement in 2001. Reporting of short interruptions (< 3 min) and interrupted power became mandatory in 2006. The interruption cost assessment has, up to 2009, been based on long interruptions and fixed cost rates for an average interruption duration and referred to a specific time of the year, week and period of the day. The interruption cost assessment in the period 2001-2008 was in principle determined according to:

$$C^*_j = c_{ref}^* \times r \times P_j$$

Where:
C^*_j = interruption cost for an interruption at time j (NOK);
C_{ref}^* = fixed cost rate in NOK/kWh at reference time, for an average duration at 2.85 hrs for non-notified and 1.3 hrs for notified interruptions respectively.

After eight years experience with fixed cost rates irrespective of duration and time of occurrence of interruptions, the cost assessment was changed to incorporate these aspects. The CENS arrangement from 2009 comprises both short and long interruptions based on the mandatory reporting of interruptions. The cost of a single interruption is calculated using the following method, taking duration and time of occurrence of the interruption into account:

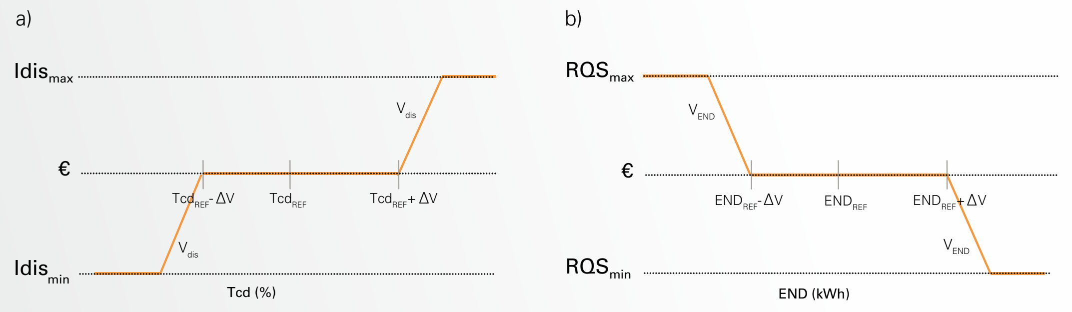
$$C_j = c_{ref}(r) \times f_{Ch} \times f_{Cd} \times f_{Cm} \times P_{ref}$$

Where:
C_j = interruption cost for an interruption at time j (NOK);
$c_{ref}(r)$ = cost rate in NOK/kW for duration r;
P_{ref} = Interrupted power in kW at reference time;
f_{Ch}, f_{Cd}, f_{Cm} = correction factors for time of occurrence (hour, day, month) per customer group.

The cost functions and correction factors are given for each of the six customer groups in the regulations (agriculture, residential, industry, commercial, public, large industry). The monthly variation is represented by a factor per month. There are three factors describing the weekly variation divided in Mondays through Fridays, Saturdays and Sundays/holidays, respectively. The daily variation is separated in six periods of the day. If the duration of an interruption affects more than one of the periods covered by the correction factors, a weighted average for the time periods should be used. If the interruption is planned and communicated to customers a reasonable amount of time prior to the interruption, six reduction factors are defined for Cj, one for each customer group. CENS is not paid to the customers directly but is linked to the implemented revenue cap formula. The companies may, however, enter into individual agreements with customers for direct payment of CENS. Such agreements are only allowed for customers with an expected use of electricity above 400,000 kWh per year and require agreed-upon cost rates for non-notified and notified interruption of varying interruption durations. Further, the cost rates must be calculated based on the expected costs for the specific customer and the agreement shall include any assumption upon which the calculation is based. Generally, interruption costs are included in the cost base for the calculation in the revenue cap and are also included in the benchmarking. All costs in the revenue cap are historic costs from two years earlier, as are the interruption costs. The allowed revenue for a company in a certain year is that year's revenue cap minus the actual interruption costs in that year.

Portugal also relies on a combination of rewards and penalties for transmission and DSOs. The relevant indicator for the transmission level is the 'combined average availability rate', expressed in % (Tcd). The incentive is symmetric and tied to a target/reference value of Tcd (Tcd_{ref}) with a dead band being addressed as well. The scheme is illustrated by Figure 2.14.

FIGURE 2.14 | Portuguese incentive scheme, a) transmission level, b) distribution level



The incentive scheme is applied with a two-year delay and the calculation method is based on historical values (the average values from 2004 until 2008). This was done to establish the parameters for the first year of the scheme. The design of the incentive scheme uses comparable incentives as a reference, such as the schemes in Great Britain and Spain. The parameters of the scheme are the following:

$Idis_{t-2}$ = Transmission availability system incentive, expressed in Euros;
$Idis_{min,t-2}$ = Maximum reward value, expressed in Euros;
$Idis_{max,t-2}$ = Maximum penalty value, expressed in Euros;
Tcd_{t-2} = Combined average availability rate, expressed in %;
$Tcd_{ref,t-2}$ = Reference value for the combined average availability rate, expressed in %;
$Tcd_{ref,t-2\pm\Delta V}$ = Neutral part of the incentive, expressed in %;
±ΔV = Dead band, variation of Tcd_{ref}, expressed in %;
$V_{Idis,t-2}$ = Valorisation of the combined average availability rate, expressed in Euros.

The reference value for the combined average availability rate $Tcd_{ref,t-2}$ is calculated according to:

$$Tcd_{ref,t-2} = \alpha \times Tdcl + (1-\alpha) \times Tdtp$$

Where:
α = Weighting factor calculated as the relation between the line circuits average thermal capacity and the sum of the line circuits average thermal capacity and the power transformers average power;
Tdcl = Line circuits average availability rate, expressed in %;
Tdtp = Power transformers average availability rate, expressed in %.

If Tcd_{t-2} is higher than $Tcd_{ref,t-2}$-ΔV, which means that the network had a good performance, the TSO will get a reward (increase of revenues) calculated as:

$$Reward_t = -V_{Idis,t-2} \times [(Tcd_{ref,t-2} + \Delta V) - Tcd_{ref,t-2}]$$

If Tcd_{t-2} is lower than Tcd_{ref}+ ΔV, which means that the network had a bad performance, the TSO will have to face a penalty (decrease of revenues) calculated as:

$$Penalty_t = V_{Idis,t-2} \times [Tcd - (Tcd_{ref,t-2} + \Delta V)]$$

If the value of Tcd in a given year is close to the reference value Tcd_{ref}, the revenue of the TSO is not affected (if $Tcd_{ref,t-2}-\Delta V \leq Tcd_{t-2} \geq Tcd_{ref,t-2}+\Delta V$, then $Idis_{t-2}=0$).

The parameters are fixed for the regulatory period 2009 to 2011, whereby the following values were used:

- As the system is symmetric, the reward and the penalty have the same maximum value: $Idis_{max,t-2} = Idis_{min,t-2}$ = 1,000,000 € (approx. 0.34% allowed revenues of the activity of energy transmission)
- Target value: $Tcd_{ref,t-2}$ = 97.5%;
- ΔV = 0% (no tolerance band);
- $V_{Idis,t-2}$ = 1,000,000€;
- α = 0.75

The incentive scheme for the distribution network is comparable to the one implemented at transmission level since it follows the same principle. In this case, the system is based on historical values as well, but also considers the quality of the service level of other European countries. It uses a combination of rewards and penalties in addition to a dead band. However, the indicator which used for distribution networks is END, which implies that an optimisation of the value represents a minimisation problem (maximisation in the case of the availability rate). The incentive scheme at distribution level uses the following parameters:

RQS_{t-2} = Distribution continuity incentive (revenues for quality of supply), expressed in Euros;
$RQS_{min,t-2}$ = Maximum penalty value, expressed in Euros;
$RQS_{max,t-2}$ = Maximum reward value, expressed in Euros;
END_{t-2} = Energy not distributed, expressed in kWh;
$END_{ref,t-2}$ = Reference value for energy not distributed (target), expressed in kWh;
$END_{ref,t-2\pm\Delta V}$ = Neutral part of the incentive, expressed in kWh;
±ΔV = Dead band, variation of END_{ref}, expressed in (kWh);
$V_{END,t-2}$ = Valorisation of Energy Not Distributed (€/kWh);
RQS_{min} = Maximum amount of the penalty (€).

The reference value for the combined average availability rate $END_{ref,t-2}$ is calculated according to:

$$END_{ref,t-2} = \beta \times ED_{t-2}$$

Where:
β: Rate of non-availability;
ED: Energy supplied in the year.

If END_{t-2} is lower than $END_{ref,t-2}$-ΔV, which means that the network had a good performance, the DSO will get a reward (increase of revenues) calculated as:

$$Reward_t = -V_{END,t-2} \times [(END_{ref,t-2} + \Delta V) - END_{t-2}]$$

If END_{t-2} is higher than $END_{ref,t-2}$+ ΔV, which means that the network had a bad performance, the DSO will have to face a penalty (decrease of revenues) calculated as:

$$Penalty_t = V_{END,t-2} \times [(END_{ref,t-2} + \Delta V) - END\,]$$

If the value of END in a given year is close to the reference value $ENd_{ref,t-2}$, the revenue of the DSO is not affected (if $END_{ref,t-2} - \Delta V \leq END_{t-2} \leq END_{ref,t-2} + \Delta V$, then $RQS_{t-2}=0$).

The scheme for the distribution network has been adapted in the past, i.e. the incentive scheme demands some improvements over time. The parameters for the 2003-2005 period were the following:

- Reward and penalty with the same value: $RQS_{max,t-2}$ = $RQS_{min,t-2}$ = 5,000,000€ (approx. 0.55% allowed revenues of the activity of energy distribution)
- Target: $END_{ref,t-2} = 0.0004 \times ED_{t-2}$
- Tolerance band: $\pm\Delta V = 0.12 \times END_{ref,t-2}$

The tolerance band was set considering the historical values of END and making sensitivity analyses about the impact of different values for the dead band. It takes into consideration that is not possible to exactly reach the reference value.

The scheme has been adopted according to the following changes:

2006: $TIEPI_{ref}$ = 92% TIEPI 2004;
2007: $TIEPI_{ref}$ = 92% TIEPI 2006;
2008: $TIEPI_{ref}$ = 92% TIEPI 2007;
2009: $TIEPI_{ref}$ = 94% TIEPI 2008;
2010: $TIEPI_{ref}$ = 94% TIEPI 2009;
2011: $TIEPI_{ref}$ = 94% TIEPI 2010

Where:
END = ED x TIEPI / T

Slovenia also uses a combination of rewards and penalties for continuity regulation of distribution networks. The scheme is fully flexible regarding the indicators used, the levels of penalties and rewards, quality classes, dead bands, etc. In general, the parameters and indicators are specified for one regulatory period but can be extended as needed. For the regulatory period 2011-2012, the indicators considered are the SAIDI and SAIFI values.

The structure of the incentive scheme is defined through a mathematical model based on a set of linear functions applied in different areas (the so-called "method of classes with interpolation on their borders"). It is defined and applied separately for each distribution area (in the current regulatory period it is not applied to a particular area type (urban, mixed, rural)). A certain constant band (constant economic effect) is applied for each quality class and a linear function is defined in the range between the quality classes. This is introduced for the same reason as in the case of a so-called dead-band: to avoid its effect on the tariff level (optimising the administrative costs) caused by non-structural changes in level of continuity of supply (i.e. stochastic variations around the reference of a certain class). It is defined by the reference standards calculated each year by applying the requested improvement on the initial (starting) level of the continuity of supply using SAIDI and SAIFI. Improvements in continuity levels are demanded on a yearly basis, as long as the long-term reference level has not been reached. However, the reward/penalty scheme is capped and also floored (to a certain percentage of controlled costs for O&M). Capping is applied since the NRA has not yet completely verified/validated the customer information on the marginal valuation of quality. The incentive scheme is floored to 2% (penalty) and capped to 0% (reward) of controlled operation and maintenance costs. The rewards are not applied due to the fact that the NRA hadn't obtained legal powers to perform "on-site" audits in the past. Sufficient legal powers have been assured since 1 January 2011. The quality scheme is linked via a "quality factor" ("q") to the implemented revenue cap scheme (building blocks approach) for the period 2010-2012. The revenue is calculated according to the following formula:

$$Rcy \leq (1 + f(CPI) - f(x) \pm f(q))Rpy \pm \Delta C$$

Where:
Rcy = Revenue of the current year;
Rpy = Revenue of the previous year;
ΔC = Compensation

Thus, the quality incentive affects the tariff (all customers contribute according to their type) in such a way that the amount of the incentive is defined through the equalisation mechanism on the DSO level which results in the change in tariff (reduction/increase) in the next regulatory period. The "q", in fact, influences the controlled costs of operation and maintenance per distribution area. The penalties and rewards are calculated on a yearly basis, aggregated and then applied to the tariffs for the next regulatory period.

Spain applies a scheme that uses rewards for TSOs and incentives for DSOs. The continuity indicators are TIEPI and NIEPI which are similar to ASIDI and ASIFI. Different areas are considered separately. Smaller DSOs with less than 100,000 customers are excluded from the scheme. The incentive scheme does not use a dead band and does not require minimum improvements. The incentives (rewards, penalties, others) are not proportional to the difference between the actual performance level and the standard (or target). The amount of the incentives is funded by customers who pay for it through access tariffs.

The calculation/estimation method of the incentive scheme for DSOs is as follows:

Order ITC/3801/2008 of 26 December modified the formula defined by Royal Decree 222/2008 to calculate the quality incentives received by distribution companies. The incentive for quality improvements is calculated for each distribution company. Each firm receives or pays yearly. Incorporated in its remuneration for distribution activity is an incentive to quality improvement, which is calculated for each distribution company according to the following formula:

$$Q^{i}_{n-1} = QTIEPI^{i}_{n-1} + QNIEPI^{i}_{n-1}$$

Where:

$$QTIEPI^{i}_{n-1} = PTIEPI \times [Pot^{i}_{tz,n-1} \times (TIEPI^{i}_{tz\text{ - }OBJECTIVO,n-1} - TIEPI^{i}_{tz\text{ - }REALIZADO,n-1})]$$

$$QNIEPI^{i}_{n-1} = PNIEPI \times [Cli^{i}_{tz,n-1} \times (NIEPI^{i}_{tz\text{ - }OBJECTIVO,n-1} - NIEPI^{i}_{tz\text{ - }REALIZADO,n-1})]$$

$QTIEPI^{i}_{n-1}$ = reward or penalty given to distribution company "i" in the year "n", associated to the compliance with the TIEPI target levels;
$QNIEPI^{i}_{n-1}$ = reward or penalty given to distribution company "i" in the year "n", associated to the compliance with the NIEPI target levels;
PTIEPI = unitary incentive associated to the TIEPI (100c€/Kwh);
PNIEPI = unitary incentive associated to the NIEPI (150c€/client and interruption);

$Pot^{i}_{tz,n-1}$ = installed power of distribution company "i" in zone type "tz" (according to Order ECO 792/2002, described previously) in the year "n-1";
$Cli^{i}_{tz,n-1}$ = number of customers of distribution company "i" in each zone type "tz" in the year "n-1";
$TIEPI^{i}_{tz\text{-}OBJETIVO,n-1}$ y $NIEPI^{i}_{tz\text{-}OBJETIVO,n-1}$ = target indicators for each zone "tz" in force in the year "n-1"; and
$TIEPI^{i}_{tz\text{-}REALIZADO,\,n-1}$ y $NIEPI^{i}_{tz\text{-}REALIZADO,\,n-1}$ = indicators of the degree of compliance with the target values.

Target (Objetivo) indicators for each company are calculated as follows:

$$TIEPI^{i}_{tz\text{-}OBJECTIVO,n-1} = 1/3 * \frac{\sum_{k=n-6}^{n-4} [TIEPI^{i}_{tz,k} + TIEPI^{medianacional}_{tz,k}]}{2}$$

$$NIEPI^{i}_{tz\text{-}OBJECTIVO,n-1} = 1/3 * \frac{\sum_{k=n-6}^{n-4} [NIEPI^{i}_{tz,k} + NIEPI^{medianacional}_{tz,k}]}{2}$$

Values for Observed (Observado) indicators for each company are calculated as follows:

$$TIEPI^{i}_{tz\text{-}REALIZADO,n-1} = 1/3 * \sum_{k=n-3}^{n-1} TIEPI^{i}_{tz,k}$$

$$NIEPI^{i}_{tz\text{-}REALIZADO,n-1} = 1/3 * \sum_{k=n-3}^{n-1} NIEPI^{i}_{tz,k}$$

The quality incentives vary between -3% and 3% of the distribution company's total remuneration.

The **Swedish** incentive scheme for the regulation period 2012 to 2015 uses rewards and penalties for DSOs. The indicators applied are SAIDI and SAIFI on the distribution level and ENS as well as interrupted power for regional networks (40-130 kV) and for transmission network (220-400 kV). The Swedish electrical power system consists of a national and regional transmission system in addition to local distribution networks. The national transmission system includes mostly 220 kV and 400 kV AC lines as well as most of the interconnectors with neighbouring countries. The national grid is owned by Svenska Kraftnät. The regional networks typically consist of 20/40/70 kV to 130 kV lines. The main function of the regional networks is to transport electricity from the national transmission network to local distribution networks and directly to some larger electricity users. There are currently 5 regional network operators in Sweden and approximately 170 local distribution networks.

The reference for all indicators is determined as the average level for the period ranging from 2006 to 2009 for both distribution and regional networks. For the TSO, the reference for all indicators is determined by the average values for the period 2001 to

2010. Also, only interruptions longer than 1 minute are taken into account for the TSO.

For DSO and regional networks, interruptions longer than 12 hours are excluded from the regulation, as direct compensation to individual customers applies in that case. The expected continuity level is not differentiated according to different areas and is individual for each of the 170 network companies. Incentives are calculated according to a linear model with a cap/floor at a maximum full rate of return of +/- 3% of the yearly regulated revenue to protect the small network operators and customers. Moreover, customer cost estimations may be biased. The amount of the incentives is funded by the customers in each network area according to the following models for unplanned and planned interruptions:

For SAIDI:

$$QSAIDI = [((SAIDInorm - SAIDIexperienced)/60) \times (Ey/Ty) \times PE] \times 0{,}5$$

For SAIFI:

$$QSAIFI = [(SAIFInorm - SAIFIexperienced) \times (Ey/Ty) \times PW] \times 0{,}5$$

Where:
PE = customer cost per kWh;
PW = customer cost per kW; and
Ey/8760 = the annually average power for the customers.

Note that PE and PW are different for planned and unplanned interruptions.

2.8.4. Regulation at single-user level and economic compensation

Various countries employ incentives at single-user level, as presented in Table 2.17 below. 18 countries offer individual compensation to network users when standards are not met. Individual compensation is not in place in 8 countries: Austria, Cyprus, Denmark, Germany, Greece, Latvia, Luxembourg and the Slovak Republic. However, Greece and the Slovak Republic are planning to introduce compensation payments in the future.

In 16 countries, the network user has the right to be reimbursed (or to receive reduction of network tariffs) after a very long interruption. In 4 countries, compensation relates to a maximum number of interruptions in one year. In 5 countries, compensation applies for planned interruptions, with different implementation solutions (related to the duration or to the notice).

In Great Britain and The Netherlands, customer research has been used to determine the compensation level for interruptions at the individual customer level. Other countries have different methods to determine compensation, such as estimation of the cost of the interruption, percentage of yearly network tariff or international comparison.

TABLE 2.17 | Standards for which economic compensation applies

Type of standard	Country adopting the standard	Standard value	Automatic compensation
Maximum duration of each unplanned interruption	BG, CZ, GB, HU, IE, IT, LT, NL, NO, PL, RO, SI: reimbursement EE, FI: percentage of network tariff FR, SE: discount on the network tariff	Ranging 1 - 24 hours	EE, FI, HU, IT, NL, PT, ES, SE
Maximum yearly duration of unplanned interruption for single user	PL: discount proportionate to price of interrupted power		
Maximum yearly number of interruptions (long or short or both) for single user	HU (short), IT (MV users) PT: reimbursement ES (MV users): percentage of yearly bill		HU (if complaint legitimate), IT, PT, ES
Maximum duration (or yearly duration) of planned interruption for single user	IT, RO: reimbursement PL: discount proportionate to price of interrupted power		
Single-user advance notice or other rules for planned interruptions	CZ: percentage network tariff IE: reimbursement	2 days	
Contractual commitments not fulfilled	FR: case by case basis		

The compensation standards are not uniform. For instance, countries like Ireland and Great Britain differentiate between business and domestic customers and offer different compensation levels accordingly. In Ireland, domestic customers who have been out of power for longer than 24 hours after contacting their supplier can get a 65€ refund, while business customers can receive 130€ for the same duration of a power outage. Great Britain employs a similar programme, with domestic customers eligible for 54£ for the first 18 hours of interruption, and business customers eligible for 108£. Ireland offers additional compensation for planned interruptions. If the supplier fails to notify a customer at least 2 days in advance, domestic and business customers are eligible for 35€ and 130€ in compensation, respectively. However, this does not apply to very short interruptions. On the other hand, customer type does not determine a compensation level in countries like Norway or Poland.

Estonia, Hungary, The Netherlands and Portugal take voltage levels into account. In The Netherlands, the level of the compensation depends both on a customer's voltage level and the voltage level where the interruption was caused. Furthermore, the compensation is differentiated by the capacity of the connection of a customer (greater than or less than and equal to 3x25A) and for interruptions of up to 8 hours varies between 35€ and 910€, depending on the voltage, as illustrated for The Netherlands in Table 2.18 below.

In addition to voltage levels, Portugal takes into account the geographical location. In Hungary, both type of customer and the voltage level are considered. The compensation rates vary between approximately 20€ and 113€. Slovenia takes a different approach to customer voltage levels and reimburses only the MV customers. The reimbursement mostly depends on the customer's load. In France, only compensation for interruptions longer than 6 hours follows precise rules, with customers getting an automatic 2% discount on the fixed part of the network tariff for every 6 hours of interruption. Compensation which may be due if contractual agreements are not met is dealt with on a case by case basis, which can lead to discriminatory practice.

In most countries (Bulgaria, the Czech Republic, Great Britain, Ireland, Lithuania, Norway, Poland, Romania and Slovenia) a customer *has the right* to be reimbursed after a long interruption. Sweden, on the other hand, offers automatic financial compensation to customers (12.5% of the annual network costs, both variable and fixed charges with a minimum of 90€) if the interruption lasts between 12 hours and up to 24 hours. For longer interruptions, the compensation level is 25% for each period of 24 hours, with a maximum of 300% of the total annual network cost, i.e. 12 days of interruption. Other countries offering automatic compensation when the standards are not met are Estonia, Finland (most network operators), Hungary (including the

TABLE 2.18 | Compensation levels in The Netherlands

	Interruption caused by a failure in a network with a voltage ≤ 1kV	**Interruption caused by a failure in a network with a voltage > 1kV and < 35kV**	**Interruption caused by a failure in a network with a voltage ≥ 35kV**
For each connection ≤ 3x25A	35€ for an interruption of 4 to 8 hours, plus 20€ for each subsequent unbroken period of 4 hours.	35€ for an interruption of 4 to 8 hours, plus 20€ for each subsequent unbroken period of 4 hours.	35€ for an interruption of 4 to 8 hours, plus 20€ for each subsequent unbroken period of 4 hours.
For each connection > 3x25A	195€ for an interruption of 4 to 8 hours, plus 100€ for each subsequent unbroken period of 4 hours.	195€ for an interruption of 2 to 8 hours, plus 100€ for each subsequent unbroken period of 4 hours.	195€ for an interruption of 1 to 8 hours, plus 100€ for each subsequent unbroken period of 4 hours.
When customer is connected to a network with a voltage ≥ 1kV and < 35kV		910€ for an interruption of 2 to 8 hours, plus 500€ for each subsequent unbroken period of 4 hours.	910€ for an interruption of 1 to 8 hours, plus 500€ for each subsequent unbroken period of 4 hours.
When customer is connected to a network with a voltage ≥ 35kV			0.35€ per contracted kW for an interruption of 1 to 8 hours, plus 0.20€ per contracted kW for each subsequent unbroken period of 4 hours.

maximum number of short interruptions affecting a customer), Portugal, Spain and The Netherlands. Norway has a direct compensation scheme for very long interruptions (>12 hours). This is implemented as a way to give the network company an incentive to fix an outage as quickly as possible: if there is an outage for more than 12 hours, the company has to pay a direct compensation to the end users affected by the outage. The compensation amount increases with the duration of the outage, but is not differentiated according to the type of customer. The amounts are: NOK 600 for an interruption of 12-24 hours, NOK 1400 for an interruption of 24-48 hours, NOK 2700 for an interruption of 48-72 hours. For interruptions longer than 72 hours, the compensation is NOK 1300 for each 24-hour period (after 72 hours).

Compensation levels can be determined by a regulator (e.g. Ireland, Norway, Portugal, Romania), through international comparison (e.g. Hungary), customer research (e.g. Great Britain), as a percentage of network tariffs/fees (e.g. the Czech Republic, Estonia, Finland, Sweden) or by the estimated cost to the customer of an interruption (e.g. The Netherlands). In some cases, compensation levels have been capped. The cap can be set as amounts (e.g. up to 160€ in Romania), as a percentage of network tariffs (300% in Sweden), as a percentage of the values set by guaranteed standards (GS) (200% in Slovenia) or as a percentage of a customer's annual energy bill (10% in Portugal and Spain). In France, the compensation for interruptions longer than 6 hours is limited to 100% of the fixed part of the grid tariff, whereas no limits for other compensation exist. In Finland, the maximum reimbursement is equal to a customer's yearly network tariff or 700€ a year, whichever is less.

Not all CEER members monitor the performance of their continuity standards and the actual amount of compensation paid to customers. Of the countries that responded on this issue, Bulgaria, Lithuania, Poland and Romania do not collect data on the performance/compensation relation.

Finally, for exceptional events (e.g. force majeure, security reasons or interruption due to a customer), compensation is either not applicable, or the levels are different than those for "usual" events. Sweden and The Netherlands offer no compensation to their customers if the interruption results from a failure in a network with a voltage of 220 kV or higher. Only in Norway are customers compensated in all conditions if an interruption lasts longer than 12 hours.

2.8.5. Historic evolution of existing incentive/ penalty regimes and experiences

Reaching the most optimal level of continuity of supply, improving the performance of network operators, sustaining a high level of electricity quality and eliminating differences between the continuity of supply in different distribution areas were just some of the reasons cited for introducing incentive regimes. Implementation did not commence simultaneously in every location. Moreover, the monetary effects of regulation were sometimes delayed with respect to the start of the incentive regulation. Such is the case in Denmark and The Netherlands. The NRAs were usually responsible for the regulatory implementation; however, in Great Britain, the incentives for continuity of supply resulted from customer research conducted by Market and Opinion Research International MORI.

Interruption indicators have been monitored in France since the 1980s. After initial monitoring of interruptions, most countries waited between 2 (e.g. Denmark, Portugal) and 7 years (Ireland) to introduce an incentive regime. The approaches chosen to implement the incentive regimes were generally communicated to stakeholders (including the utilities) by consultations, benchmarking reports, meetings and public hearings. In the case of The Netherlands, a consultation paper was drafted in which different possibilities regarding quality regulation were presented. The network operator's comments, such as the reliability of the data on interruptions, were taken into consideration and as a consequence the regime began with no financial penalties.

Direct consultation has also been applied in Great Britain, Ireland and especially in Slovenia, where regular consultation workshops and meetings of the Quality of Supply WG comprised representatives from all stakeholders and where the accent has been placed on intensification of open dialogue between the stakeholders. The Irish NRA has extended its incentive scheme beyond the initial period, while Great Britain introduced rewards as well. In Hungary, the NRA issued a proposal for stakeholders prior to introducing the incentive regime. Finnish stakeholders were informed about the local incentive regime through regulatory decisions and guidelines. In a similar fashion, a benchmarking report was used in Denmark. In some countries (Slovenia, Hungary, Lithuania), the introduction of incentive regimes has initially not been accepted with enthusiasm, whereas others (Great Britain, Norway) saw a positive initial acceptance. In Ireland, it is interesting to note that compensation for failing to restore the power supply within a predetermined time or failing to give advance notice about a planned interruption to a customer has existed and was put in place by the DSO even before the establishment of the NRA.

The incentive regimes have already been changed in certain countries. In Great Britain, the incentive rates were amended to correspond to the values that customers attribute to interruptions. In Ireland, a dead-band for SML has been introduced for the 2011/2012 incentive period to combat the varying (and difficult-to-predict) SML output. The effect of a Q-Factor has been increased in The Netherlands by changing the indicators used to determine the Q-Factor and splitting the SAIDI into a combination of CAIDI and SAIFI. A graduation has been introduced in Denmark to make the penalty fairer. Norway has changed its regime several times. In Portugal, the regime has remained the same but the parameters have changed to become more demanding each year. The regime has not been changed in Hungary, but a long-term target for what should be achieved by yearly improvements has been set.

2.8.6. Expected developments in continuity of supply and quality incentives

Without a doubt, quality incentive regulation will change in the future. Many countries that have not yet implemented it will do so, while others will focus on improving their regulation. For example, preparations are underway for extra compensation for the maximum planned unavailability in France's transmission network. This year, the Danish incentive will introduce data on duration of the interruption at single-customer level. There are plans to introduce individual guaranteed continuity standards in Greece, the Slovak Republic and Slovenia. In Greece, compensation will be paid if the restoration time for a single interruption exceeds a limit or if the yearly number of interruptions greater than a specified duration exceeds a cetain limit. The Slovak Republic is planning to introduce automatic compensation payments while Slovenia and Spain are planning to extend their compensation scheme for the next regulatory period.

Of the countries with no overall incentive-based scheme, Austria and Romania are considering introducing a link between continuity and tariffs. Incentive regulation based on SAIDI and SAIFI indicators is planned by Greece and the Czech Republic, whereas Luxembourg is taking quality incentives into consideration. Germany will introduce a reward-penalty mechanism in 2012 (the last two years of the first regulatory period), with the following details already available: SAIDI will be considered on a LV level and ASIDI on the MV level. The mechanism will only be applied to DSOs with more than 30,000 customers. Rewards or penalties for each network operator will be calculated depending on a difference between the network operator's continuity level and a reference level of all network operators. The difference will be multiplied by a fixed price for quality per unit and by the number of customers from the network operator. The price for quality will be estimated by the NRA by using a macroeconomic approach. Both the operator's continuity level and the continuity reference level are calculated as a mean of continuity indicators for the past 3 years. The reference level takes structural differences (measured as load density) into account. Whether the quality improves or not will be left for the individual network operator to decide as the minimum improvements will not be determined by the NRA. The aim of the quality regulation system in Germany is to achieve a socio-economically acceptable level of continuity of supply. There will be no tolerance/dead band, but a cap and floor system (set to a fixed percentage of allowed revenues) will be implemented for rewards and penalties. The incentive scheme will act as an additive element of the revenue cap, which is modified depending on the performance of the network operator in terms of continuity of supply. Hence, the existing revenue-cap of the network operator increases or decreases with quality of supply. In general, the total amount of all rewards should be equal to the overall amount of penalties of all network operators.

2.9. Findings and Recommendations on Continuity of Supply

Finding #1

Continuity of supply is monitored in all countries

Monitoring schemes for continuity of supply are in place in all 26 CEER countries who participated in the data collection survey for this report. Monitoring continuity of supply is an essential tool in the overall monitoring by an independent entity (such as a regulator) of a functioning electricity market. In addition, most countries in the ECRB (see dedicated ECRB Annex of this Benchmarking Report), Belgium (who did not participate in the survey) and Switzerland, see dedicated inset in Section 2.4.5) monitor continuity of supply. Thus, continuity of supply is monitored in at least 35 European countries.

Such monitoring usually covers long interruptions (more than three minutes) by differentiating unplanned (non-notified) and planned (notified) interruptions. All 26 countries that provided feedback monitor unplanned interruptions and 24 of them monitor planned interruptions. Short interruptions are recorded separately by 12 of the 26 respondents and 4 countries record transient interruptions separately. Other countries record short and transient interruptions without a separate definition, so they are included in long or short interruptions respectively. Slightly more than half of countries (17 out of 26) consider incidents at all voltage levels in the continuity of supply statistics.

Recommendation #1

Expand the monitoring of continuity of supply

Incidents at all voltage levels should be included in interruption statistics. As long as the duration of those interruptions and the numbers of affected network users are estimated, the additional costs are limited. A decision at national level is needed on automatic methods for determining the duration and number of affected users for incidents at LV. The costs of such a scheme should be considered in that decision.

It is recommended that the measurement of interruptions should cover all network levels and all interruption durations.

Finding #2
Continuity of supply indicators, procedures for data collection vary across countries

European countries use different indicators and different weighting methods when evaluating interruptions, in fact, a range of indicators is in use in different countries. The use of multiple indicators to quantify the continuity of supply enables the collection of more information and offers more possibilities to observe trends. In the 4th Benchmarking Report, CEER presented precise definitions of continuity indicators in order to ensure harmonisation between European countries. SAIDI and SAIFI are the most commonly-used indices with weightings in most countries based on the number of users.

The analysis in Section 2.5.2 further reveals that the number of short interruptions per year (MAIFI and more frequently MAIFIE) is used in nearly all countries that monitor short interruptions. However, as discussed in Section 2.6.3, the use of MAIFIE (aggregation rules) differs in the 5 countries which use a MAIFIE-like index.

The indices ENS and AIT are frequently used to monitor continuity of supply in transmission networks. Section 2.6.5 reported ENS values for 14 countries.

Most of the countries collect some information on the cause of interruptions. If collected in detail, this provides NRAs with important information on the grid and can be used as an essential part of the improvement of continuity of the supply by the network operators. Different designations and meanings of exceptional events are used in the CEER Member Countries[9].

Recommendation #2

Harmonise continuity of supply indicators and data collection procedures

CEER recommends standardisation of data collecting procedures for NRAs, with a single scheme for continuity of supply indicators, which must be tied to:

- the duration and frequency of long interruptions: SAIDI and SAIFI;
- the frequency of short interruptions: MAIFIE; and
- the ENS due to interruptions in the transmission networks: ENS.

Moreover, countries should be encouraged to use the same weighting methods for indices with the same term. CEER recommends the harmonisation of continuity of supply methods by NRAs through the usage of common definitions for indicators and common rules for weighting. Common rules for aggregation should be investigated and pursued by CEER, before more countries begin to use short interruption indices.

Lastly, CEER confirms its recommendation that any publication of continuity of supply data include information on the interruptions that are excluded and included.

9. See Section 2.7 of the 4th Benchmarking Report and Annexes of that report.

Finding #3
Continuity of supply improvements tend to become stable

The data presented in Section 2.6 shows different tendencies in continuity of supply across CEER countries.

The difference in the yearly cumulative duration of interruptions (excluding exceptional events) across the countries tends to diminish over the years. At least 5 countries which were seeing a high number of minutes lost around the year 2000 now have duration figures similar to those of the other countries.

More generally, around half of the countries with data covering at least three years (9 out of 15) show a decreasing duration of interruptions. In the other 6 countries (characterised by good or even very good continuity level since the beginning), the duration is almost on the same value.

The number of interruptions across the countries has smaller variations when compared to the changes in the duration of the interruptions. In most countries, the number has the same long-term tendency, but it is interesting to observe that in at least 4 countries there is a decoupled trend, which reflects a shorter or a longer average duration of the individual interruptions.

7 countries reported data for short interruptions covering at least 4 years. From this limited sample, an increased stability of the indicator over the years can be observed. Still, it is worth noting that half of the countries have a decreasing number of short interruptions.

Whereas the data for distribution systems are characterised by a substantial stability in the figures over the years, the interruption indices for transmission systems are clearly affected by more frequent yearly spikes, which are probably due to the large effects of a limited number of events.

Recommendation #3

Investigate continuity of supply trends for a periodic review of regulation.

CEER recommends that the competent regulatory authorities analyse trends in continuity of supply and (when applicable) the economic results of regulation. Periodic evaluation and revision of the continuity regulation are suggested, with enlargements and adaptations over time.

Finding #4
Continuity of supply varies depending on the population density and the voltage level

5 countries provided data for continuity of supply linked to population density (urban/suburban/rural areas, see Section 2.7.1). In each of these 5 countries, continuity of supply is much better in urban areas than in rural areas.

About 70% of SAIDI and about 78% of SAIFI are due to incidents at MV, based on data obtained from, respectively, 6 and 5 countries (see Section 2.7.2). For SAIDI, the spread between the countries was small, between 61% and 79%. For SAIFI, the spread between the countries was between 59% and 85%. For the contributions from incidents at other voltage levels, the percentages vary strongly between these countries.

Recommendation #4

Assess disaggregated continuity data in order to identify priorities

CEER recommends that NRAs and network operators collect and assess disaggregated interruption data, for example by voltage level and by cause, in order to better identify priorities for regulation and network interventions.

Finding #5
Continuity of supply levels are affected by network characteristics

Section 2.7.5 analyses the correlation between the percentage of underground cables and continuity of supply in several European countries. It shows a significant correlation between a high percentage of underground cables and high continuity of supply. This correlation tends to confirm existing observations and statements on the benefits of undergrounding for continuity of supply. However, many indicators are actually correlated all together: the population density, the resources available for networks, the continuity of supply and the many parameters that impact it, such as the percentage of underground cables, the redundancy of the networks or the quality of the preventive maintenance. As a consequence, it is not possible to assess precisely the specific impact of the percentage of underground cables on continuity of supply.

Recommendation #5

Promote cost-benefit analysis to improve the efficiency of expenditure on networks

CEER recommends the use of cost-benefit analyses to compare and select the various actions (e.g. undergrounding) aimed at improving continuity of supply. The results of such cost-benefit analyses should be shared between countries.

Finding #6

Incentive schemes are used to regulate continuity of supply in distribution and transmission networks

General reward or penalty schemes or incentives to optimise the continuity of supply levels (on a system level) are applied in 15 out of 26 countries.

Penalties are usually coupled with rewards and are always applied to distribution networks. 11 countries adopt rewards and/or penalties for transmission networks as well. 6 countries (Austria, the Czech Republic, Germany, Greece, Luxembourg and Romania) which have not yet implemented a continuity of supply rewards/penalties scheme plan to introduce such a regime. Whereas other countries focus on combining penalties and rewards, Denmark and Hungary have regimes that focus exclusively on penalties.

Minimum improvements for DSOs are sometimes required. This is the case in Bulgaria, France, Great Britain, Hungary, Ireland, Italy, Portugal and Slovenia. Additionally, a tolerance band (the so-called deadband) where no reward or penalty exists is used in Finland, Hungary, Ireland, Portugal and Slovenia.

The data obtained by cost estimation studies is frequently used to set incentive schemes (rewards/penalties and compensation levels) for network operators.

Recommendation #6

Implement an incentive scheme for maintaining or improving general continuity levels

CEER recommends that NRAs implement adequate incentive schemes in order to maintain continuity of supply levels or improve them, if economically viable on both the distribution and the transmission levels.

CEER confirms its past recommendation that the results from cost-estimation studies on customer costs due to electricity interruptions are of key importance in order to be able to set proper incentives for continuity of supply.

Finding #7

Incentive schemes for individual continuity levels are used in many countries and have different formulations

Compensation schemes at single-user level are applied in 18 countries and are planned in 2 others. In 16 countries, the network user has the right to be reimbursed (or to receive a reduction in network tariffs) after a very long interruption, varying across the countries from 1 hour for HV users to 24 hours for domestic users. In 4 countries, compensation is associated to the maximum number of interruptions in one year. In 5 countries, compensation is linked to planned interruptions as well.

The schemes, however, are not uniform, as reported in Section 2.8.4. For example, some countries differentiate between business and domestic network users while others differentiate between the voltage levels. In some cases, the compensation levels depend both on the connection voltage level and the voltage level where the incident that caused the interruption took place. In some cases, user location and load are also taken into account.

Sometimes the reimbursements are automatic (Estonia, Finland, Hungary, Italy, Portugal, Spain, Sweden and The Netherlands). Methods to determine compensation levels vary from a percentage of network tariffs to an estimation of the costs of the interruption based on customer surveys.

Recommendation #7

Implement compensation payments for network users affected by very long interruptions

CEER recommends that the monitoring of interruptions is extended to a customer survey at single-user level to provide the basis for individual compensation schemes.

CEER recommends the standardisation of payments among the European countries. However, compensation payments should depend on the respective connection level.

Finding #8
More countries participate in benchmarking continuity

The series of CEER Benchmarking Reports on Quality of Electricity Supply have demonstrated the importance of a continued exchange of information on quality indicators, actual quality levels, standards, regulatory mechanisms and strategies.

The basic recommendations of the 1st Benchmarking Report can today be considered to have been achieved completely:

- publication of the report to promote discussion of quality regulation amongst EU and non-EU regulators;
- enlargement of the membership of the dedicated CEER Working Group to include members from other countries; and
- submission of the findings for discussion to a suitable international conference on regulatory issues.

A significant enlargement in membership and participation is observed in the Benchmarking Reports. The publication of the benchmarking reports with a minimum common structure through all its editions has reduced the cost of obtaining information about regulation.

Recommendation #8

Exchange information on continuity of supply and its regulation

CEER recommends that NRAs continue exchanging best practices on regulating electrical network industries, as done in the benchmarking reports.

3.

Voltage Quality

3.1 What is Voltage Quality and why is it important to regulate it?

Voltage quality (VQ) covers a wide range of voltage disturbances and deviations in voltage magnitude or waveform from the optimum values. In this benchmarking report, voltage quality is used to refer to all disturbances (excluding interruptions which are covered by Chapter 2). Examples of voltage disturbances are supply voltage variations, harmonic voltage and voltage dips. We do not include details of frequency variations in this report; these are deemed to be rather a system operation issue.

Voltage quality is becoming an increasingly important issue in many countries due to, among other things, increases over the last 20 to 30 years in the susceptibility of end-user equipment and industrial installations to voltage disturbances, and the increased emission of disturbances by end-user equipment. The increased susceptibility and emission levels are causing an increase in costs for network users as a result of voltage disturbances. This could result in an increase in network tariffs in order to mitigate these disturbances. Future developments, like increasing amounts of distributed generation and the increased use of energy-efficient equipment, could result in further increases in emissions.

Voltage quality is by far the most technically-complex part of quality of electricity supply. Measurement issues, the choice of appropriate indicators, and the setting of limits require detailed monitoring of every single disturbance. The disturbance level and the consequences of high disturbance levels are further determined by multiple stakeholders. This often makes it difficult to lay the responsibility with one particular stakeholder, whether it's the network operator or one of the connected end-users. Responsibility sharing has been identified by CEER as an important principle for voltage quality regulation.

At European level, the "3rd Package" Directive 2009/72/EC [27], which had to be transposed by Member States by 3 March 2011, states that the regulatory authority shall have the duty of setting or approving standards and requirements for quality of supply or contributing thereto together with other competent authorities (Article 37(1h)). This provision is expected to result in a further increase in the involvement of national regulators in voltage quality issues, which thus far have not been fully addressed by national regulators in every European country.

The European standard[10] EN 50160 [22] gives an overview of all voltage quality disturbances and sets limits or indicative values for many of them. This document has become an important basis for voltage quality regulation throughout Europe. A further important contribution comes in the form of the standard on power-quality (PQ) measurements, EN 61000-4-30 [31], which has resulted in common methods for voltage quality monitoring.

The ultimate aim of voltage quality regulation is to ensure that the functioning of equipment is not impacted by voltage disturbances coming from the network. Such malfunctioning can never be completely ruled out, but the probability of it occurring is kept low in Europe through a set of standards on electromagnetic compatibility issued by IEC (International Electrotechnical Commission) and taken over by CENELEC (European Committee for Electrotechnical Standardization) as European harmonised standards, together with the European EMC Directive [26]. These documents regulate the emission of disturbances by individual devices as well as by installations and regulate the immunity of individual devices to any disturbances. Although the spread of disturbances across the electricity network is taken into consideration when setting the various limits, additional regulation of network operators in terms of voltage quality is necessary. This concerns, among other things, the setting of maximum levels of voltage disturbances at the point of delivery between the network operator and its customers, and responsibility sharing between the different stakeholders, for instance in terms of emission limits for installations. Any voltage quality regulation must consider both the costs for customers due to equipment malfunctioning or damage and any direct or indirect increase in tariffs due to improvements made in the grid.

Whereas interruptions affect all network users, voltage disturbances do not affect all users in the same way. Also, the impact of different types of disturbances can be completely different for different individual users. Whereas there is a need for harmonisation as regards limits on voltage disturbances (as end-user equipment is the same throughout Europe), the emphasis in regulation is likely to be different between European countries, due to the aforementioned reasons.

3.2 Main Conclusions from Past Activities of the European Energy Regulators on Voltage Quality

The 1st and 2nd Benchmarking Reports on Quality of Electricity Supply [1] [2] devoted their attention to continuity of supply and commercial quality. CEER began to address voltage quality in 2005, when preparing the 3rd Benchmarking Report on Quality of Electricity Supply [3]. CEER's activities in this area deepened with papers on 'Towards Voltage Quality Regulation in Europe' [11] and other reports and events, which are summarised in Table 3.1.

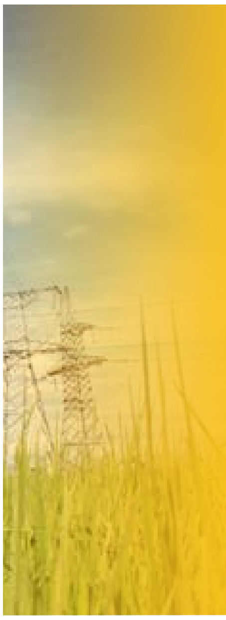
In 2006, CEER also promoted cooperation on voltage quality with the European standardisation organisation CENELEC, mainly in order to revise the European standard EN 50160. The outcome of this cooperation is discussed in Section 3.4.1, together with the ERGEG (European Regulators Group for Electricity and Gas) conclusions following its public consultation on regulation of voltage quality. Eurelectric (sector association of the electricity industry in Europe) was one of the most active parties in the EN 50160 revision process, as witnessed by the CEER/Eurelectric round tables at CIRED 2009 and CIRED 2011 (International Conference on Electricity Distribution).

The 3rd Benchmarking Report on Quality of Electricity Supply concluded that:

- A good knowledge of actual voltage quality levels is a preliminary step towards any kind of regulatory intervention;
- A process was (in 2005) on-going in many countries for voltage quality monitoring (VQM);
- Network users were generally entitled to get a verification of actual voltage quality levels at their point of connection; and
- In some countries, network users and distribution operators had the possibility to agree upon contractual quality levels and related payments.

The 3rd Benchmarking Report recommended:

- The monitoring and publication of most critical voltage quality performances; and
- Further research on power quality contracts.



10. In this chapter the term 'standard' refers to a technical specification for repeated or continuous application, with which compliance is not compulsory, and which can be an international standard, a European standard, a harmonised standard on the basis of a request by the European Commission or a national standard. The rules for individual voltage parameters are usually referred to as 'limits' or 'requirements' when they relate to voltage quality (whereas they are normally called 'standards' when relating to continuity of supply or commercial quality).

TABLE 3.1 | Main activities of the European Energy Regulators on voltage quality

Title of the report or description of the activity	Date	Reference
3rd Benchmarking Report on Quality of Electricity Supply	December 2005	C05-QOS-01-03
CEER cooperation with CENELEC on "Voltage characteristics of electricity supplied by public electricity networks"	2006 - on-going	EN 50160:2010
Public Consultation Paper "Towards Voltage Quality Regulation in Europe"	December 2006	E06-EQS-09-03
Conclusions Paper "Towards Voltage Quality Regulation in Europe" (and evaluation of comments paper)	July 2007	E07-EQS-15-03
E. Fumagalli, L. Lo Schiavo, F. Delestre, "Service quality regulation in electricity distribution and retail"	2007	Book by Springer Verlag
4th Benchmarking Report on Quality of Electricity Supply	December 2008	C08-EQS-24-04
Round table "CEER/Eurelectric cooperation on continuity of supply and voltage quality requirements and incentives"	June 2009	RT.2b @ CIRED 2009
CEER-Eurelectric workshop on voltage quality monitoring	November 2009	-
CEER Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances and accompanying "Study on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances"	December 2010	C10-EQS-41-03 TR F6978
Final Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas	February 2011	E10-RMF-29-05
CEER-Eurelectric Round Table "Voltage quality monitoring, dip classification and responsibility sharing"	June 2011	RT.2a @ CIRED 2011

The 2006 handbook on "Service quality regulation in electricity distribution and retail" [12] (developed as a joint effort by CEER and the Florence School of Regulation) acknowledged that 'voltage quality is not an issue for beginners' and mapped the limited practices of voltage quality regulation into 4 regulatory instruments:

- Publication of data;
- Minimum requirements/standards;
- Reward-penalty schemes attached to standards;
- The adoption of power quality contracts.

Before adopting any of these instruments, the handbook commented on the availability of reliable measurements as a very critical issue, especially in the area of voltage quality.

The 4th Benchmarking Report on Quality of Electricity Supply [4] assessed in 2008 the monitoring schemes for voltage quality in 11 countries. It concluded that these schemes suffered from a lack of harmonisation in terms of 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. Most importantly, for the first time the report included data on actual voltage quality levels submitted by 6 countries (France, Hungary, Italy, The Netherlands, Norway and Portugal).

The 4th Benchmarking Report recommended that countries consider continuous monitoring of voltage quality, that they publish results regularly and disseminate experiences. It remarked that the obligation for system operators to provide individual verification of voltage quality upon user request should be adopted by all countries.

Following the recommendation on disseminating experiences of voltage quality monitoring, CEER in cooperation with Eurelectric organised a "Joint workshop on Voltage Quality Monitoring" on 18 November 2009. Presentations [13] were given by the main stakeholders (national regulators, large industrial customers and network operators) and a number of technical experts. All emphasised the need for monitoring of voltage quality and dissemination of the results. The technical experts addressed some of the technical complexities of voltage quality monitoring, including the interpretation and application of the monitoring results. Some national experiences were presented. They included examples of permanent monitoring being implemented in all HV/MV substations in a country.

The need for clear responsibility sharing between the relevant stakeholders was also mentioned by several presenters. Both Eurelectric and CEER included the development of this as an important task in their concluding remarks. Further important

TABLE 3.2 | Main conclusions of surveys on costs due to poor voltage quality (source: CEER 4th Benchmarking Report)

Country/year	Inhabitants	Estimated annual costs
Norway by NVE and stakeholders (2002)	Around 5 million	Estimated annual costs due to dips for end-users between 120 and 440 million NOK.
Sweden by Elforsk (2003)	Around 10 million	Estimated annual costs for industrial customers due to dips and interruptions at about 157 million €.
Italy by AEEG and Politecnico di Milano (2006)	Around 60 million	Estimated annual costs due to dips and interruptions (< 1 s) for the whole production system between 465 and 780 million €.
Pan European survey by Leonardo Power Quality Initiative (2005-2007)		Costs of PQ wastage EU-25 exceeds 150 billion € annually.

conclusions were the need for increased awareness and participation among network users and the need for the relevant stakeholders to remain involved in international expert groups like those sponsored by CIGRE (International Council on Large Electric Systems) and CIRED.

The problems and costs of voltage quality disturbances were further investigated by CEER in 2010 [6]. The impact of voltage disturbances in national economies justified several surveys on costs that were carried out by different entities in Italy, Norway, and Sweden and at European level (as reported in the 4th Benchmarking Report, see pages 83-88). Table 3.2 summarises some conclusions from these surveys.

CEER's 2010 work included the commissioning of a consultancy report on "Estimation of Costs due to Electricity Interruptions and Voltage Disturbances" [20]. The consultancy report found that activity in this area is at differing levels of development across European countries. CEER deemed it useful to try to set out European guidelines of good practice in the domain of nationwide studies on the estimation of costs. In addition to joint guidelines for continuity and voltage quality, the CEER recommendations covered a few additional aspects of costs due to voltage disturbances, specifically for case-based voltage quality studies: the deployment of measurement instruments, the logging of events and the analysis of log forms and measurement data.

CEER concluded that the results from cost-estimation studies on customer costs due to voltage disturbances are an important input for determining the consequences of various voltage disturbances when deciding where to focus regulation. A second conclusion by CEER was that the national regulatory authorities (NRAs) should perform nationwide cost-estimation studies regarding electricity interruptions and voltage disturbances.

The 4th Benchmarking Report also recommended investigating whether it is feasible to use smart meters for measuring voltage quality parameters in an efficient way. With regard to the optional use of smart meters for voltage quality issues, the European Energy Regulators expressed in the Guidelines of Good Practice on Smart Metering (2011) [10] their understanding that smart metering and voltage quality monitoring systems are likely to remain differentiated in the future. Most of the smart meters that are currently available cannot provide the same level of information as dedicated power-quality instruments, in compliance with EN 61000-4-30 [31] and other international standards. Still, information on voltage quality is not considered necessary for all supply terminals. Measurements by the available meters (even if they are not performed according to standards) can provide important information on voltage deviations and can offer preliminary information for further measurements.

3.3 Structure of the Chapter on Voltage Quality

This chapter first describes standards and requirements for voltage quality. Standards and requirements encompass standardisation activities at European level and national legislation and regulations. It summarises the outcome of the cooperation process between CEER and CENELEC, which led to important improvements in the EN 50160 standard on voltage characteristics in Europe. The chapter also contains a comparison of voltage quality regulations, including national rules which differ from EN 50160, which ensure individual verification of voltage quality, provide individual information about voltage quality and define emission limits by customer installations.

Next, the chapter provides details on the monitoring schemes applied in the CEER countries and data on actual voltage quality levels submitted from those countries where such data is available, including information on the publication of voltage quality data.

The chapter is based on input from 25 CEER countries: Austria, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, the Slovak Republic, Slovenia, Spain and Sweden.

3.4 Voltage Quality Legislation, Regulation and Standardisation

3.4.1 Improvements to the new version of EN 50160

The European Energy Regulators listed 6 recommendations for the improvement of European standard EN 50160 during the consultation process carried out in 2006-2007:

- Improve definitions and measurement rules;
- Enlarge the scope of EN 50160 to high voltage (HV[11]) and extra-high voltage (EHV) systems;
- Adopt new limits for voltage variations, avoiding "95%-of-time" clause and long time intervals for averaging measured values;
- Avoid ambiguous indicative values for voltage events and introduce a classification of severity of voltage dips and swells;
- Introduce limits for voltage events according to network characteristics; and
- Consider the duties and rights of all parties involved and propose a general framework to share responsibility between network companies, equipment manufacturers and users.

The CEER conclusions paper on "Towards Voltage Quality Regulation in Europe" [11] underlines that EN 50160 can be used as a basis for national voltage quality regulations only if certain improvements in the standard are made. To this extent, CEER offered its cooperation on the work necessary for revising standard EN 50160. CEER is currently also cooperating with CENELEC in the drafting of a new edition of TR 50422, the application guide to EN 50160 which was published in 2003 [32].

CEER fully shares the conclusion of the 19th Electricity Regulatory Forum (Florence Forum, December 2010) that the standardisation process "should take full account of its regulatory fast paced development". This warning to the European Standardisation Organisations to speed-up the standardisation process was confirmed by the European Commission in its Communication on Standardisation 1 June 2011 [28]. Unfortunately, the current experience of CEER cooperation with CENELEC regarding this fundamental element of the network regulation framework (the voltage quality standards) suggests that results are not easily achievable at a fast pace.

After 5 years of cooperation between CEER and CENELEC, the positive elements in the new standard EN 50160:2010 [22] include:

- An improved structure, dividing continuous phenomena and voltage events;
- Improved (more unique) definitions for voltage dips and swells;
- Standardised classification tables for voltage dips and swells;
- The applicability of the standard up to and including 150 kV (although requirements are much weaker than for MV and LV);
- Improved limits for supply voltage variations in the MV network;
- The removal of a note weakening the limits of supply voltage variations, when customers are being supplied "in remote areas with long lines or not connected to a large interconnected network"; and
- The removal of ambiguous indicative levels for voltage events (e.g. "the expected number of voltage dips in a year may be […] up to one thousand") from the normative part of the standard.

11. See Section 2.4.3. for the CEER classification of voltage levels.

TABLE 3.3 | Standard EN 50160 - summary

Voltage disturbance	Voltage level	Voltage quality index (limit)
Supply voltage variations	LV	• 95% of the 10 minute mean r.m.s values for 1 week (±10% of nominal voltage). • 100% of the 10 minute mean r.m.s values for 1 week (+10% / -15% of nominal voltage).
	MV	• 99% of the 10 minute mean r.m.s values for 1 week below +10% of reference voltage and 99% of the 10 minute mean r.m.s values for 1 week above -10% of reference voltage. • 100% of the 10 minute mean r.m.s values for 1 week (±15% of reference voltage).
Flicker	LV, MV, HV	• 95% of the Plt values for 1 week.
Unbalance	LV, MV, HV	• 95% of the 10 minute mean r.m.s values of the negative phase sequence component divided by the values of the positive sequence component for 1 week (0% - 2%).
Harmonic voltage	LV, MV	• 95% of the 10 minute mean r.m.s values for 1 week lower than limits provided by means of a table. • 100 % of the THD values for 1 week (≤8%).
	HV	• 95% of the 10 minute mean r.m.s values for 1 week lower than limits provided by means of a table.
Mains signalling voltages	LV, MV	• 99% of a day, the 3 second mean value of signal voltages less than limits presented in graphical format.

CEER retains its view that standard EN 50160 can be satisfactory from a regulatory point of view only if certain improvements are made. The main improvements still needed are:

- An effective extension to the high voltage networks (with effective limits and requirements) and the consideration of extra high voltage networks;
- The adoption of new limits for supply voltage variations in distribution networks (especially in low voltage networks);
- The introduction of limits for voltage events, taking into account the different characteristics of the European networks; for voltage dips and voltage swells one or more responsibility-sharing curves should be defined; and
- A general framework for sharing the voltage quality responsibilities between network companies, equipment manufacturers and users.

3.4.2 Limits for voltage disturbances in the new version of EN 50160

Standard EN 50160 remains the basic instrument for voltage quality assessment in the reporting countries.

EN 50160 sets limits for 4 voltage disturbances using 1 or 2 voltage quality indices for each of these disturbances. In the case of supply voltage variations, limits are set only for LV and MV networks (see Table 3.3).

3.4.3 National legislation and regulations that differ from EN 50160

9 countries have introduced requirements which differ from those in EN 50160. In addition, France has adopted contractual limits. These different requirements are more restrictive, as regards either the percentage of time for which violations of the limits are allowed (use of indices which correspond to higher percentiles), the limits themselves (lower values for the same voltage quality index), or the use of shorter integration periods. Countries with different requirements are presented in Tables 3.4, 3.5 and 3.6. Voltage quality indices different from the indices used in EN 50160 are also shown in these tables. More details are given in Part 1 of the Annex to Chapter 3.

The following additional major deviations from EN 50160 can be reported (see also the overviews in the 4th Benchmarking Report):

- The 1 minute root-mean-square (r.m.s.) for the voltage quality index for supply voltage variations is used in Hungary and in Norway;
- Sweden has, since the publication of the 4th Benchmarking Report, introduced new voltage quality regulation. The same limits as in EN 50160 are used but the limits should not be exceeded for 100% of time; and
- There are still no requirements for the following voltage disturbances: transient overvoltages, interharmonic voltages, mains signaling voltage and DC component.

TABLE 3.4 | Voltage quality regulation differing from EN 50160 – supply voltage variations

Voltage disturbances	Indicator	Integration period	Time	Limit	Country (voltage level)
Supply voltage variations	r.m.s. voltage	10 min	95%	±7.50% of U_N	HU (LV)
	r.m.s. voltage	10 min	100%	±10% of U_N	HU (LV), SE (HV,MV,LV)
	r.m.s. voltage	1 min	100%	+15% / -20% of U_N	HU (LV)
	r.m.s. voltage	10 min	95%	±5% of U_N	PT (HV)
	r.m.s. voltage	10 min	95%	±7% of U_N	ES (MV, LV)
	r.m.s. voltage	1 min	100%	±10% of U_N	NO (LV)
	r.m.s. voltage	10 min	95%	±10% of U_N	NL (MV)
	r.m.s. voltage	10 min	100%	+10% / -15% of U_N	NL (MV)
	r.m.s. voltage	10 min	99.9%	±10% of U_N	NL (HV)
	r.m.s. voltage	10 min	95%	+5.33% / -4.66% of U_N	IT (HV) [150 kV, normal]
	r.m.s. voltage	10 min	100%	+10% / -6.66% of U_N	IT (HV) [150 kV, normal or alarm]
	r.m.s. voltage	10 min	100%	+13.33% / -14.66% of U_N	IT (HV) [150 kV, emergency or restoration]
	r.m.s. voltage	10 min	95%	±5.30% of U_N	IT (HV) [132 kV, normal]
	r.m.s. voltage	10 min	100%	+9.84% / -9.09% of U_N	IT (HV) [132 kV, normal or alarm]
	r.m.s. voltage	10 min	100%	+13.6% / -15.15% of U_N	IT (HV) [132 kV, emergency or restoration]
	r.m.s. voltage	10 min	100%	+10% / -15% of U_N	IT (MV) [temporary islanding operation of normally interconnected MV networks]

Note (1): for HV no supply voltage variations limits are given by the EN 50160
Note (2): The measurement period for all the above requirements is 1 week

TABLE 3.5 | Voltage quality regulation differing from EN 50160 – other variations

Voltage disturbances	Indicator	Integration period	Time	Limit	Country (voltage level)
Flicker	P_{st}	-	95%	≤ 0.35	CY (HV, MV, LV)
	P_{lt}	-	95%	≤ 0.35	CY (HV, MV, LV)
	P_{st}	-	95%	≤ 0.8	CZ (HV, MV, LV)
	P_{lt}	-	95%	≤ 0.6	CZ (HV, MV, LV)
	P_{st}	-	100%	≤ 0.85 (planning level)	IT (HV)
	P_{lt}	-	100%	≤ 0.62 (planning level)	IT (HV)
	P_{st}	-	95%	≤ 1.2	NO (MV, LV)
	P_{st}	-	95%	≤ 1	NO (HV)
	P_{lt}	-	100%	≤ 1	NO (MV, LV), PT (HV)
	P_{lt}	-	100%	≤ 0.8	NO (HV)
	P_{st}	-	100%	≤ 1	PT (HV)
	P_{lt}	-	100%	≤ 5	NL (HV, MV, LV)
Voltage unbalance	V_{un}	10 min	95%	≤ 1%	IT (HV)
	V_{un}	10 min	100%	≤ 2%	NO (HV, MV, LV), SE (HV, MV, LV)
	V_{un}	10 min	100%	≤ 3%	NL (MV, LV)
	V_{un}	10 min	99.9%	≤ 1%	NL (HV)
Harmonic voltage	THD	10 min	100%	≤ 3%	IT (HV)
	THD	10 min	100%	≤ 8% 0,23 ≤ U ≤ 35 kV ≤ 3% 35 ≤ U ≤ 245 kV	NO (HV, MV, LV)
	THD	1 week	100%	≤ 5%	NO (MV, LV)
	Individual	10 min	95%	Table	PT (HV)
	Individual	10 min	100%	Table	NO (HV, MV, LV)
	Individual	10 min	100%	Table (as in EN 50160)	SE (HV, MV, LV)
	THD	10 min	95%	≤ 8% U < 35 kV ≤ 6% 35 ≤ U < 150 kV	NL (HV, MV, LV)
	Individual	10 min	99.9%	Table U < 35 kV	
	THD	10 min	99.9%	≤ 12% U < 35 kV ≤ 7% 35 ≤ U < 150 kV	

Note (1): The measurement period for all the above requirements is 1 week

TABLE 3.6 | Voltage quality regulation differing from EN 50160 – events

Voltage disturbances	Indicator	Integration period	Time	Limit	Country (voltage level)
Voltage dips	The dip-table is divided in the three areas A, B and C (see Case study 4).				SE (HV, MV, LV)
Voltage swells	The swell-table is divided in the three areas A, B and C.				SE (HV, MV, LV)
Single rapid voltage change	Number of voltage changes per 24 hours.			$\Delta U_{steady\ state} \geq 3\%$: ≤ 24 $0.23 \leq U \leq 35$ kV ≤ 12 35 kV $< U$ $\Delta U_{max} \geq 5\%$: ≤ 24 $0.23 \leq U \leq 35$ kV ≤ 12 35 kV $< U$	NO (HV, MV, LV) SE (HV, MV, LV)
	Number of voltage changes per hour.			< 1 $\Delta U_{max} = 3$ [1–10] $\Delta U_{max} = 2.5$ [10–100] $\Delta U_{max} = 1.5$ [100–1000] $\Delta U_{max} = 1$	CZ (HV)

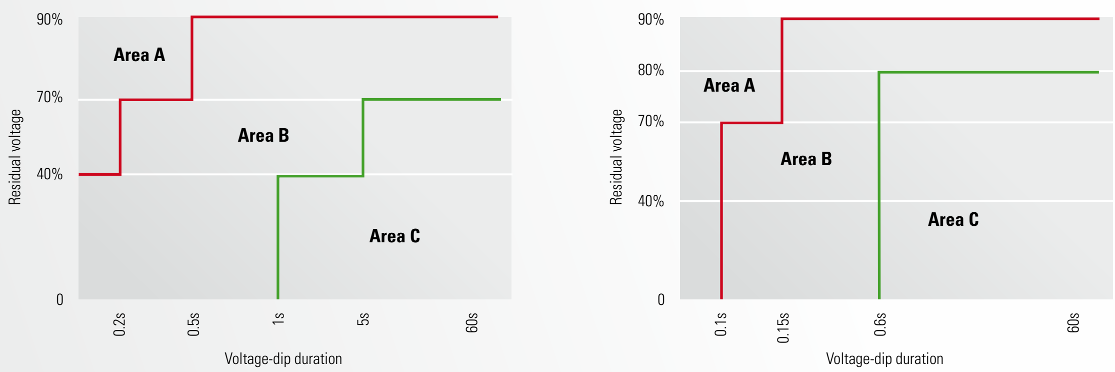
Case Study 4

Voltage dip regulation in Sweden

Swedish Regulation EIFS 2011:2, of 28 April 2011, aims to define the conditions that must be fulfilled for the voltage to be considered to be of good quality. The regulation covers supply voltage variations, harmonic voltages, voltage unbalance, voltage dips, voltage swells, and single rapid voltage changes. The regulation for voltage dips and voltage swells is based on the "responsibility-sharing curve" as was introduced in the 2006 ERGEG public consultation paper on voltage quality. The curves used in the Swedish regulation are shown in Figure 3.1 below.

The regulation states the following: "There shall not be any voltage dips in Area C" and "The network operator has the responsibility to mitigate voltage dips in Area B to the extent that the mitigation measures are reasonable in relation to the inconvenience for electricity users that are related to the voltage dips". Dips in Area A are counted as single rapid voltage changes and are somewhat limited in this sense. Note that, beyond Area C, there are no specific numerical limits on the number of voltage dips. It must be determined, for every individual case, whether the number of dips is acceptable or not. However, the regulation gives the following general recommendation: "When assessing what are reasonable mitigation measures in relation to the inconveniences for example historical data, other similar networks under similar circumstances, technical possibilities, and costs for mitigation might be considered."

FIGURE 3.1 | Classification of voltage dips in 3 areas, up to and including 45 kV (left), and above 45 kV (right)



3.4.4 Obligations for monitoring voltage quality

An important aspect of overall regulation is the monitoring of voltage quality parameters in such a way that it provides a system-wide evaluation of the voltage quality and its evolution in time.

In a number of countries (see Table 3.7), the distribution system operators (DSOs) are obliged to perform voltage quality measurements, either on a continuous basis (the Czech Republic, Hungary, Norway, Slovenia and - starting from January 2012 - Italy) and/or during shorter but predefined periods of time, e.g. 1 or more weeks at each location (Austria, Lithuania, The Netherlands and Portugal). Different voltage quality disturbances are monitored in the different countries. However, the requirements and test methods from standard EN 50160 are used as a reference in most of the countries. Monitoring is performed mainly in permanent locations with the emphasis being placed on substations (HV/MV and MV/LV). In Hungary, LV monitoring is performed in order to identify circuits with voltage problems (this information is then taken into account in network development design) or to evaluate the results of network development.

For transmission system operators (TSOs), the monitoring obligation is, in most cases, limited to voltage magnitude. Extensive monitoring (in terms of the number of voltage quality disturbances measured) is performed in Italy, The Netherlands, Norway and Slovenia. The measurements are performed mainly at the connection points with customers (HV customers and distribution networks).

In Norway, the TSO and all DSOs are obliged to perform continuous monitoring of voltage dips, voltage swells and rapid voltage changes (since 2006). The companies are obliged to group their grids into characteristic networks and to perform measurements within each characteristic network, for voltage levels above 1 kV. The TSO/DSOs are responsible for the number of instruments needed to provide credible statistics (the minimum requirement is at least one instrument, but this is applicable only for the smallest DSOs). Results from continuous monitoring are stored for at least 10 years.

3.4.5 Individual voltage quality verification

In a number of countries, if a customer wants to monitor voltage quality at his/her own connection point, the DSO or the TSO is compelled to provide a voltage quality monitor (see Table 3.8). For the rest of the reporting countries, it appears that voltage quality monitoring is performed even if the TSO or the DSO is not legally obliged to do so. In Slovenia, a predefined payment is set (the predefined charges vary per utility and on average are around 400€ per week according to the tariff for supplementary services). However, in practice, the DSO will charge the customer only after a series of unjustified complaints – the customer is notified that any new measurement will be charged. In some countries, the customer pays only if the measurements are found to be within the limits (Bulgaria, the Czech Republic, Hungary, Latvia, Poland and Slovenia). It is important to highlight that the customer, in order to take advantage of the monitoring service, must be informed about all the relevant aspects, including the cost of the service. Therefore, all the relevant procedures must be described in detail.

With respect to individual voltage quality issues, penalties or other sanctions are applied in the majority of reporting countries. 3 different approaches have been identified:

1) Customer compensation by the network operator according to the conditions of a contract between the customer and the network operator (Bulgaria, France and Germany);

2) Customer compensation by the network operator in case of a violation of the overall voltage quality limits (Finland, Hungary, Lithuania, Poland and Slovenia) or in case of a late response to a measurement request by a customer (Hungary); and

3) Monetary penalties applied to the network operator in the case of mishandling of a voltage quality problem, e.g.:
   - Late response (the Czech Republic and Ireland);
   - Problem not resolved (Italy);
   - Mitigation measures ordered by the NRA are not taken (Sweden); and

TABLE 3.7 | Measurement obligations

Network	Countries
Distribution	AT, CY, CZ, HU, IT (2012), LT, LU, NL, NO, PT, SI
Transmission	BG, CY, HU, IE, IT, LT, LU, NL, NO, PT, SI

- Problems relating to certain provisions, including rectification without undue delay, notification from end-users, customer treatment, monitoring and information (Norway).

Customer compensation is set in different ways. In Finland, according to the contracts between the customer and the network operator, customer compensation is provided in terms of a reduction in network charges (higher than 4% of the annual network charges of the customer). In Slovenia, a customer can claim the cost of damages due to a voltage quality problem provided that the damage and its relationship to violation of the limits of the standard EN 50160 can be documented. For Hungary, see Case study 5.

Case Study 5

Customer compensation in Hungary for supply voltage variations

The regulation prescribes that the voltage variation should be within 230 V ± 7.5% (95% of the 10 minute r.m.s. voltage value for 1 week) and ±10% (100% of the 10 minute r.m.s. voltage value for 1 week), and further within +15% and -20% for all 1 minute r.m.s. voltage values. According to the regulation, if the requirements above are not met, the DSO compensates the consumer according to the following scheme: once in the first year, quarterly in the first half of the second year, and monthly from the second half of the second year, until the problem is resolved.

Compensation is set considering the European experience as described in the 4th Benchmarking Report. 3 different groups of customers are considered in the compensation scheme:

A. Household customers: approx. 18€.
B. LV non-household customers: approx. 36€.
C. MV non-household customers: approx. 109€.

Until 2009, compensation was paid to consumers upon request. Since 2010, the DSO is obliged to compensate consumers automatically within 30 days from the date that the consumer complaint was verified.

In 2009, the DSO paid a total of approx. 16,000€ and in 2010, a total of approx. 43,000€ in compensations to customers. For 2010, 96.7% of the compensation was for LV customers and the rest (3.3%) for MV customers.

In Norway, the TSO and all DSOs are obliged to perform measurements to verify the levels of all relevant voltage quality parameters upon complaints from customers, including end-users, producers or other grid companies (since 2005). The measurement period shall be at least 1 week and shall, as far as possible, reflect the operating conditions related to the complaint. The costs associated with the complaint handling and the measurements shall be covered by the TSO/DSOs. The TSO/DSOs are also obliged to carry out measurements of some parameters upon request, even if the customer experiences no problems. In the latter case, the measurement costs may be transferred to the customer.

TABLE 3.8 | Individual voltage quality monitoring

Network	Countries where the network operator is compelled to provide a voltage quality recorder (upon request of a customer) or where it is common practice to provide it
Distribution	AT, BG, CY, CZ, FI, FR, GR, HU, IT, LV, LT, LU, NO, PL, RO, SI
Transmission	AT, CY, CZ, FI, FR, LV, LT, LU, NO, PL, PT, SI
Common practice	IE, NL, SE

In most countries, a customer can install his/her own voltage quality recorder when the results are to be used in a dispute between the customer and the DSO or TSO. However, there is no extensive experience regarding this issue. In general, the voltage quality recorder must comply with technical standards (for example EN 61000-4-30) and be accepted by the network company.

3.4.6 Individual information on voltage quality

In a few of the reporting countries, the network operators are obliged to inform customers about the actual voltage quality levels (in practice, the measured levels from the recent past). In Ireland, the DSO must provide information upon the request of a customer. The type of information is based on the request. The TSO is not obliged to inform customers about voltage quality levels, but if issues arise customers will be informed. In Italy, the network operators are obliged to publish and/or inform EHV, HV and MV customers about the maximum and minimum short circuit power at the connection point. In Portugal, the network operators are obliged to provide the parameters as in the Quality of Service Code. In The Netherlands, a customer is entitled to information only if there is a measuring unit installed at his connection point. The information provided to customers in Norway is presented in Case study 6 and in Slovenia in Case study 7.

Case Study 6

Information provided to customers about past (or expected future) voltage quality levels in Norway

At the request of a current or future network customer, the TSO/DSOs shall provide information within 1 month on the continuity of supply and voltage quality in their own installations. Information on the following elements shall be provided:

a. Nominal value for the supply voltage in connection points and voltage quality limits;
b. Results of fault analyses carried out pursuant to the regulations relating to system responsibility;
c. Results of continuous monitoring of voltage quality parameters;
d. Estimated number of historical and expected voltage swells and voltage dips in the company's own supply areas, based on historical data recorded through continuous monitoring;
e. 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; and
f. 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 transient over-voltages, use of automatic reconnection, etc.

Grid companies may not demand special remuneration for information provided pursuant to the aforementioned paragraphs. Based on actual measurements at a given point in the network, the TSO/DSOs shall provide information about the level of steady state voltage variations, flicker severity, degree of voltage unbalance and harmonic voltages, when so requested in writing by current or future customers. The TSO/DSOs may demand the reimbursement of necessary costs for carrying out the obligations pursuant to this paragraph.

Case Study 7

Information provided to customers in Slovenia

DSOs in Slovenia are obliged to measure and report voltage quality parameters according to EN 50160 obtained by permanent voltage quality monitoring systems and measurements upon request. Permanent voltage quality monitoring is implemented at HV busbars, MV busbars and on MV side of MV/LV distribution transformers. 2 types of reports are produced using these measurements: individual and aggregated reports.

Individual reports

- Event analysis: In order to provide the appropriate level of voltage quality at the user's connection point all operational data (e.g. from SCADA (supervisory control and data acquisition)) are correlated with continuous voltage quality measurements in the case of interruptions, different voltage events (dip/swell), etc. The analysis and the produced reports are available upon request to customers, free of charge.

- EN 50160 compliance: DSOs are obliged to verify EN 50160 compliance in case of a customer complaint for a period of 1 week, based on EN 61000-4-30, for power frequency, supply voltage variations, flicker severity, supply voltage unbalance, harmonic voltage as well as mains signalling voltage. There are on average more than 350 complaints recorded per year. In more than 70% of these complaints, voltage characteristics are not EN 50160 compliant.

- Identification of voltage quality problems: DSOs, based on the results of the continuous analysis described above, report the different events and variations (flicker, harmonics, etc.) that originate from the transmission network and from industrial customers.

Aggregated reports

All collected voltage quality measurements are used to produce annual reports that are published on the web pages of the distribution utilities, the DSO (aggregation on national level) and the TSO. The regulatory authority also publishes a report on voltage quality on an annual basis.

3.4.7 Emission limits

In order to regulate the impact that customers have on the voltage quality of the networks, a number of countries have introduced legislation regarding the emissions by individual customers. 3 approaches are identified for these countries:

a. Maximum levels of current emissions are set for the installations connected to the networks: France (see Case study 8);
b. Application of international standards for the emissions of equipment connected in an installation (mainly IEC standards): Austria, Hungary, Ireland and Slovenia; and
c. Use of planning levels (the emissions from an installation should be such that the so-called "planning levels" are not exceeded): Bulgaria, Luxembourg and Poland use standard EN 50160; Ireland, The Netherlands and Slovenia refer to IEC standards (IEC 61000-3-6 [38] IEC 61000-3-7 [39] and IEC 61000-3-13 [40]); the Czech Republic and Norway refer to their national limits. Note that these IEC documents do not provide emission limits. They provide guidelines for the assessment of emission limits and indicative values for planning levels.

Note that for approach (b), limits are imposed for emissions from individual appliances/loads and in approach (c), there is a limit in voltage disturbances so that the current emissions of the entire installation (not of each individual appliance/load) should be low enough for the limit to be met. For more information regarding the role of the stakeholders, see Case study 9.

In Sweden, the network operators are to set reasonable contractual emission requirements to ensure that voltage quality for other customers is kept within the voltage quality requirements. In case of a dispute, the NRA has the right to decide if the requirements are reasonable. In Italy, the transmission grid code (enforced by the NRA) defines requirements for EHV and HV customers and a regulatory order enforces a national technical standard that defines requirements for MV customers.

In Norway, the regulation applies to those who entirely or partially own, operate or use electrical installations or electrical equipment that is connected to the Norwegian power system and those who, pursuant to the Energy Act, are designated system operators. The grid customer shall, without undue delay, inform the TSO/DSO to which they are connected about incidents in their own installations or equipment when it is likely that the TSO/DSO may experience problems complying with the provisions in the regulation. For the Norwegian requirements for specific voltage quality parameters and comparison to EN 50160, please refer to Table 3.7 in the 4th Benchmarking Report.

Penalties for customers are used in several countries for violation of the maximum levels of disturbances (see Table 3.9). In most countries, these maximum levels are defined in terms of voltages ("planning levels"), only in France are there maximum emission levels defined in terms of currents (only for harmonics). In France, penalties are foreseen in contracts between system operators and customers. Customers (producers and consumers) connected to the transmission network are required to take the necessary measures to avoid violating the maximum levels of disturbances mentioned in Case study 8. Otherwise, they have to finance the reinforcement measures taken by the TSO to withstand these disturbances and pay for the actual damages caused by them. On the distribution level, it is quite similar, with some minor differences depending on the DSO involved.

TABLE 3.9 | Penalties for customers

Countries that foresee penalties for customers
AT, BG, CZ, FI, FR, HU, IE, LT, LU, NL, NO, PT, SI

Case Study 8

Maximum level of current emissions for harmonics in France

The national decrees dealing with connection to the transmission and distribution networks impose maximum levels of disturbances emitted by users. These levels depend on the voltage level. The requirements are the same for producers and consumers on EHV, HV and MV networks (except for some rare exceptions as described below).

400 kV

The n-harmonic current shall be lower than $I_h(n) = K(n) * S / (\sqrt{3} * U)$ where S is either equal to Pmax as defined in contract, or 5% of Ssc, whichever is lower, U is the nominal voltage and K(n) is equal to: K(2)=1.8%, K(3)=3.9%, K(4)=0.9%, K(5)=4.8%, K(7)=4.8%, K(9)=1.8%, K(11)=K(13)=3%, K(6)=K(8)=K(10)=…=K(24)=0.6%, K(15)=K(17)=…=K(25)=1.8%. The total harmonic distortion shall be lower than 4.8%.

225 kV and 150 kV

The n-harmonic current shall be lower than $I_h(n) = K(n) * S / (\sqrt{3} * U)$ where S is either equal to Pmax as defined in contract, or 5% of Ssc, whichever is lower, U is the nominal voltage and K(n) is equal to: K(2)=3% K(3)=6.5%, K(4)=1.5%, K(5)=8%, K(7)=8%, K(9)=3%, K(11)=K(13)=5%, K(6)=K(8)=K(10)=…=K(24)=1%, K(15)=K(17)=…=K(25)=3%. The total harmonic distortion shall be lower than 6%.

90 kV and 63 kV

The n-harmonic current shall be lower than $I_h(n) = K(n) * S / (\sqrt{3} * U)$ where S is either equal to Pmax as defined in contract, or 5% of Ssc, whichever is lower, U is the nominal voltage and K(n) is equal to: K(2)=3% K(3)=6.5%, K(4)=1.5%, K(5)=8%, K(7)=8%, K(9)=3%, K(11)=K(13)=5%, K(6)=K(8)=K(10)=…=K(24)=1%, K(15)=K(17)=…=K(25)=3%. The total harmonic distortion shall be lower than 6%.

MV

Harmonic current (no requirement for producers whose Pmax < 100 kW and consumers < 100 kVA): The n-harmonic current shall be lower than $I_h(n) = K(n) * Pmax / (\sqrt{3} * U)$ where Pmax is defined in contract, U is the nominal voltage and K(n) is equal to: K(2)=2% K(3)=4%, K(4)=1%, K(5)=5%, K(7)=5%, K(9)=2%, K(11)=K(13)=3%, K(6)=K(8)=K(10)=…=K(24)=0.5%, K(15)=K(17)=…=K(25)=2%. The total harmonic distortion shall be lower than 6%.

LV (consumers)

Harmonic limits to be determined by the DSO depending on the location.

Case Study 9

The roles of the stakeholders with respect to emission limits for customers

DSOs are responsible for the operation of distribution systems (1); therefore most of the requirements on voltage quality are directed towards DSOs. However, voltage quality is different from other quality aspects in the sense that it is not fully determined by the DSOs. Rather, the electrical installations of connected network users may have an impact on the voltage quality in a local electricity network. This implies that different methods exist for maintaining a sufficient voltage quality, including DSOs strengthening the grid or connected customers installing preventative measures.

To prevent excessive network tariffs for customers, DSOs commonly define requirements for the emissions from (mainly industrial) customers (also known as emission limits). Typically, these requirements are set either in the Network Codes or in the connection agreement. The regulator is responsible for approving the methodologies used to calculate or establish the terms and conditions for connection and access to networks (2), i.e. the emission limits are subject to regulatory scrutiny. Both the regulator and the DSOs should ensure that the above mentioned methodologies are known to customers (3). It must be highlighted that these methodologies should include provisions for cases where the requirements cannot be met by the customers without further investments.

Furthermore, it is important to note that the existence of emission limits for customers does not imply that DSOs may neglect voltage quality issues (foreseen conditions, problems identified by measurements) in network development planning and design. All stakeholders must accept responsibility for maintaining, or achieving, good voltage quality in the distribution networks.

The emission limits can either be on current or on voltage (planning levels). In the latter case, an impedance is needed to estimate the current emission limits, which can be a reference impedance or (an estimation of) the actual impedance (see the technical reports in the IEC 61000-3-X series [38] [39] [40] for more details on this subject). The size of the customer's installation, the type of loads connected, the voltage level and the background level of disturbance are important parameters that determine the level of detail for the required analysis.

(1) Article 25(1) of Directive 2009/72/EC: *The distribution system operator shall be responsible for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency.*

(2) Article 37(6a) of Directive 2009/72/EC, "*The regulatory authorities shall be responsible for fixing or approving sufficiently in advance of their entry into force at least the methodologies used to calculate or establish the terms and conditions for: (a) connection and access to national networks, including transmission and distribution tariffs or their methodologies. Those tariffs or methodologies shall allow the necessary investments in the networks to be carried out in a manner allowing those investments to ensure the viability of the networks…;*"

(3) Article 25(3) of Directive 2009/72/EC, "*The distribution system operator shall provide system users with the information they need for efficient access to, including use of, the system*".

3.5 Voltage Quality Monitoring Systems and Data

Since the 4th Benchmarking Report, more countries have begun to monitor voltage quality (at different voltage levels). The national approaches have differed in their conception due to local conditions, with no harmonised requirements to direct them in a common direction. In particular, the reasons behind their use have varied, leading to different choices in terms of what is monitored, which (and how many) network points and voltage levels are concerned and what types of monitoring are applied. These variables make it complex to compare data from different European countries. In this 5th Benchmarking Report, the approach of major voltage dips (see section 3.5.4) is adopted to improve comparability of data.

With the (recent) introduction of smart metering in distribution grids, comes a slow but steady increase in the number of monitoring points in the distribution grids throughout Europe. However, which voltage quality parameters are being monitored varies from country to country.

With regard to smart meters, it is not so much that the meters themselves are intelligent but how they are employed in the networks.

3.5.1 Development of voltage quality monitoring systems

Voltage quality monitoring systems were reported to be operating in 14 of 25 responding countries. In addition, a VQ monitoring initiative is reported in Lithuania. Table 3.10 below provides an overview of the monitoring systems in operation, how long the systems have been running and the number of monitoring units, differentiated per voltage level. However, this does not imply that there are no voltage quality monitoring systems present in other countries: a Eurelectric survey in 2009 reported that 82% of the surveyed DSOs carry out voltage quality monitoring on a continuous basis [33]. Many network operators have access to voltage quality monitoring instruments for their own use and several even have a permanent monitoring system with many instruments in operation. Nonetheless, these systems are often for use by the network operator only. In this report, the focus is on permanent voltage quality monitoring systems as opposed to occasional voltage quality measurements, which result for example from complaints made by customers.

Table 3.10 shows that the number of monitors varies significantly between countries. France employs more than 100,000 voltage quality monitors, whereas Cyprus, Latvia and The Netherlands have less than 100 measuring instruments. The difference in size between the countries is one explanation but it fails to explain the difference completely.

Those countries that have monitoring systems do, with one exception, monitor at different voltage levels: 5 countries measure at all voltage levels, 4 countries (Austria, Cyprus, Hungary and Latvia) measure at MV and LV, 4 countries (Bulgaria, Norway, Romania and Slovenia) measure at EHV/HV and MV. Greece measures at LV. It is relevant to note that not only the number of monitors but also at which network points they have been installed is important.

In Austria, a voltage quality monitoring programme was launched from 1 April 2011. This programme includes 299 measuring units placed throughout the MV network. The choice of network points that are monitored varies from one year to the next. However, network points at which measurements have been conducted in the past will be excluded from the sample until all points are measured at least once.

TABLE 3.10 | Monitoring systems in operation: number of measuring units at different voltage levels

Country	Period of monitoring since	Number of measuring units installed			
		EHV / HV	MV	LV	Total
Austria	April 2011		299	Yes	299
Bulgaria	June 2010	495	1,372		1,867
Cyprus	Distribution: 2000 Transmission: 2010		+	+	16
Czech Republic	2006	160	694	14,525	15,379
France	EHV and HV: 1998 MV: not available LV: March 2010	208	30,000	250,000	280,208
Greece	March 2008			500	500
Hungary	2004		157	585	742
Italy	2006	165	600	(Through smart meters)	765
Latvia	1999		Yes	20	20
The Netherlands	EHV and HV: 2004 For all DSOs: 1996	28	60*	60*	28
Norway	2006	o	o	o	o
Portugal		53	101	166	320
Romania	2008	22	130#		152
Slovenia	2004	183	183		366

\+ Measurements performed in both the MV and LV networks.

* Number of measurement periods with a duration of 1 week being performed with several measuring instruments per year.

\# About 130 fixed measuring instruments are used by the DSOs in the HV and MV networks for continuous monitoring.

o The total number of instruments in Norway is not declared in detail, but given the large number of grid companies in Norway (157 DSOs in addition to the TSO), this scheme results in several hundred instruments (EHV, HV, MV).

In Bulgaria, an extensive monitoring programme measures the voltage quality at all HV substations, HV and MV end-user sites, and at all MV busbars in HV/MV substations. The total number of measuring units is 495 in the HV network and 1,372 in the MV network. Of these measurement units, 53 units are portable instruments.

In Cyprus, the voltage quality monitoring programme in the distribution network has been in operation since 1 January 2000. Since 1 June 2010, the transmission network has also been included. The monitoring system in the transmission network involves a single, permanent and fixed instrument at the TSO connection point production units. In addition, a total of 15 portable instruments are used to measure the voltage quality at the connection points of independent renewable energy producers and at MV substations.

Below are the dates from which continuous monitoring of voltage quality in the Czech Republic for different kinds of network points has been in operation. The list comes 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
- Substations output voltage 110 kV (MV)
  > continuously monitored since 1/1/2010
- Delivery points MV
  > selection
- Substations output voltage MV/LV
  > selection
- Delivery points LV
  > selection

In France, the monitoring of voltage quality began in January 1998 with a programme in the EHV and HV networks. This programme now includes measurement units at 208 EHV or HV end-user sites (the total number of end-user sites in the EHV and HV networks in France amounts to 1,720). In the MV networks, about 50% of MV customers (the total number is about 60,000 MV customers) are equipped with a monitoring device. These monitoring devices are especially installed for customers with a subscribed power larger than 250 kVA. Furthermore, some of the HV/MV substations are monitored in the distribution networks. Finally, the voltage quality monitoring programme includes around 250,000 end user sites in the LV network. All of the measuring instruments in the MV and LV networks are fixed instruments.

In Greece, since the launch in 2007 of a monitoring programme there are 500 measuring points, of which 285 interconnected urban network points and 107 interconnected rural network points. The remaining 108 measurement units were installed in networks on non-interconnected islands. Population density criteria were used in order to select end-user sites in both the interconnected distribution networks and the non-interconnected islands. The threshold for the distinction between urban and rural was placed at a population of 1,000.

In Hungary, the selection of network points for voltage quality monitoring is done according to different approaches for the LV and MV networks. In the LV network, the monitoring instruments are placed at network points with known voltage quality problems, especially at locations with large supply voltage variations. Thus, the results of the voltage quality monitoring serve as input for the network development plans of the DSOs. The average monitoring duration of LV network points is about 3 weeks. In the MV network, the selection of monitored network points is based on different approaches and its purpose is to monitor the voltage quality in general. The average monitoring duration of MV network points is about 9.6 months.

In Ireland, the TSO has a number of disturbance recorders at key nodes in the transmission network, including a number of interfaces with users of the system. The recorders monitor voltage and current and the newer installations have the ability to calculate, among other things, voltage unbalance, harmonics, etc. Currently, the TSO uses these recorders primarily to examine the impact of faults and other abnormal conditions on the power system and on users of the power system. Voltage quality parameters are not monitored on a continuous basis or at pre-defined time periods. Harmonic distortion and voltage unbalance surveys are carried out from time to time to establish network conditions prior to and/or post changes (e.g. the addition of a new feeder, customer load or reactive power support installation), in response to requests (see Section 3.4.6) and to provide data for system models.

In Italy, voltage quality monitoring in the EHV, HV and MV networks has been in operation since 2006. The following network points are monitored in Italy, including the number of measuring instruments:

- 380 kV busbar/substation 7
- 220 kV busbar/substation 16
- HV busbar/substation 142
- MV busbar in HV/MV substation 400
  (to be extended to all MV busbars from 2012)
- MV end-user site 70
- MV busbar in MV/LV substation 130
- LV end-user site 350,000
  (planned, through smart meters)

The monitoring of voltage quality in the LV networks occurs for customers equipped with smart meters. Currently, a consultation is being conducted by the regulator on the monitoring campaigns (see Section 3.5.2 on smart meters).

In Latvia, there are 20 portable instruments monitoring the voltage quality at the weakest points in the network. The weakest points are defined by the DSO without the use of standardised criteria. Generally, they refer to points in the network with long overhead lines in the LV network (more than about 500 meters), which are located mostly in rural areas. Moreover, approximately 10% of MV busbars in HV/MV substations are also monitored for voltage quality. Further, voltage quality measurements are performed only in case of complaints from customers, generally in the LV networks. In the MV networks, monitoring due to complaints from customers is typically performed only once or twice per year.

In The Netherlands, the selection of network points under monitoring (for a period of 1 week) was based on a random selection of postcodes. Since 2008, the random selection of 60 monitoring customer connection points in both the MV and LV networks is based on EAN codes rather than postcodes. In The Netherlands, a unique EAN-code is assigned to every single customer connection point, which is used for identification by network operators and suppliers. In the HV network, 20 customer connection points have been randomly selected to monitor the voltage quality continuously. From 2004, all customer connection points in the EHV network are continuously monitored.

In Norway, all voltage levels above 1 kV are involved in continuous monitoring. From 1 January 2006, all network operators are required to carry out continuous monitoring on characteristic areas in their EHV, HV and MV networks. These characteristic areas are defined by considering features such as, underground cables versus aerial lines, system earthing, extension of the network and short circuit power. The network operators decide for themselves how many measurement instruments for continuous monitoring are required to create trustworthy statistics. Each network operator must have at least one instrument installed in each different characteristic area.

The total number of instruments in Norway is not declared to the regulator in detail, but given the large number of network operators in Norway (157 DSOs regulated by revenue cap in 2010), this scheme results in several hundred instruments installed in the MV, HV and EHV networks.

The Norwegian regulator, NVE, commissioned a consultancy study [36] with the task of, inter alia, evaluating how network operators have solved the current requirements on continuous monitoring of voltage disturbances, including the number of instruments, the voltage disturbances monitored, the characteristic networks and the location of measurement units. Further, the study aimed to evaluate whether the current regulatory requirement is sufficient to ensure trustworthy statistics at national, regional and local level, and to recommend a suitable division of characteristic networks for a given number of operators. The assignment included recommendations on regulatory requirements to ensure the mentioned trustworthy statistics. Finally, the assignment included issuing recommendations on a reporting scheme of results from the measurements of voltage disturbances through continuous monitoring, or monitoring related to customer complaints or requests.

In Portugal, voltage quality monitoring is carried out at all voltage levels. The quality of service code establishes that within every 2 years, each delivery point in the EHV and HV networks must be monitored. The TSO continuously monitors all delivery points where measurement is possible. Where monitoring is conducted with portable instruments, the duration of the monitoring is 4 weeks. Furthermore, the quality of service code requires that monitoring is done in MV busbars in all HV/MV substations and in LV busbars in, at least, 2MV/LV substations per municipality for every 4 year period.

In Romania, the voltage quality monitoring system covers all voltage levels in the network. The scheme includes approximately 150 fixed and 150 portable measuring instruments. The fixed measuring instruments are used for continuous monitoring as follows: 22 instruments for the EHV network (220 – 750 kV) of the TSO and about 130 measuring instruments for the HV and MV networks of the DSOs. The network operators decide for themselves which network points need to be monitored for voltage quality. Chosen network points include, for example, representative substations, connection points between the networks of the TSO and DSO and wind power stations. The other 150 measuring instruments are used by the TSO and DSOs for limited periods of time in the case of written complaints about the voltage quality from customers. This service is mandatory for the network operators and the majority of complaints occur in the LV network.

In Slovenia, a voltage quality monitoring system has been in operation since January 2004. This monitoring system includes the EHV, HV and MV networks of both the TSO and DSO. The scheme consists of 106 fixed instruments in the EHV and HV networks of the TSO that carry out continuous monitoring at HV customer connection points and at HV/MV substations. In addition, voltage quality is monitored in the HV and MV networks of the DSO using 260 fixed measuring instruments. These instruments are placed at all MV busbars in HV/MV substations and at various points in the network that are considered to be at risk of high levels of voltage quality disturbances such as:

- Industrial MV/LV substations with connected customers with contractual power exceeding 1 MVA;
- If the LV feeder in a substation is longer than 1,000m; and
- Network points with non-linear or rapidly variable loads, for example sawmills and metallurgy.

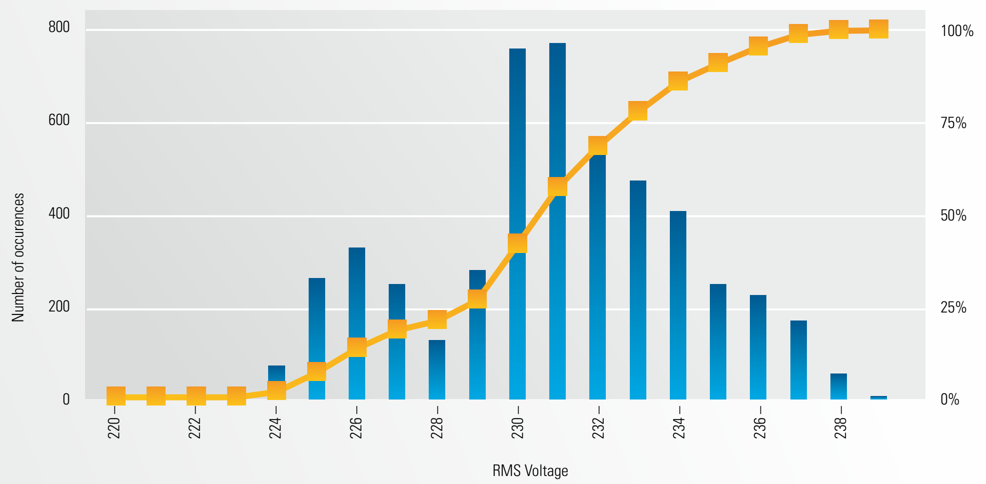
See also Case study 7 in Section 3.4.6.

Case Study 10

Voltage quality monitoring in Switzerland

The Swiss Regulator ElCom does not collect voltage quality data. Within the electricity sector, several companies are working on an individual basis on power quality monitoring solutions. Some of them already have a monitoring system in place with measuring points on all voltage levels. The association of Swiss electricity companies (VSE) aims to introduce a common tool that could be used by the whole sector. This tool is based on software developed in cooperation with a university to measure and analyse voltage quality data in accordance with standard EN 50160. They introduced this tool in 2010 and up to now a small number of network operators, representing approximately 10% of the consumption in Switzerland have participated and supplied data. The data have been collected from all voltage levels and analysed (e.g. flicker, dips, swells, harmonics, voltage unbalance and supply voltage variations). Figure 3.2 below shows an example for supply voltage variations.

FIGURE 3.2 | An example for supply voltage variations in Switzerland



The data are collected twice a year, each time for 1 week on several locations in the network.

The VSE will promote the use of their tool in the future.

Voltage disturbances monitored in the different countries are presented in Table 3.11, where abbreviations for voltage levels are used as follows:
L = Low Voltage, M = Medium Voltage,
H = High Voltage, E = Extra High Voltage.

Even though methods for measuring interharmonic voltage exist in EN 61000-4-30 [31], the monitoring of interharmonic voltage is still very rare. Continuously monitoring interharmonic voltages would, among other things, provide a basis for the setting of voltage characteristics and compatibility levels in the grid as well as emission and immunity limits for equipment.

TABLE 3.11 | Voltage disturbances currently continuously monitored in different European countries (voltages: L-low, M-medium, H-high, E-extra high, or All levels)

Voltage disturbance	AT	BG	CY	CZ	FR	GR	HU	IT	NL	NO	PL	RO	SI
Supply voltage variations	LM	LMH	LMH	LMH	All	L	LM	All	All		All		MHE
Flicker	LM	LMH	LMH	LMH	HE	L		MHE	All		All	LMH	MHE
Voltage dips	LM	LMH	LMH	LMH	MHE	L	LM	MHE	HE	MHE	All	LMH	MHE
Voltage swells		LMH	LMH	LMH	HE	L	LM	MHE	HE	MHE		LMH	MHE
Transient overvoltages		LMH			MV				HE				
Voltage unbalance	LM	LMH		LMH	MHE	L	LM	MHE	All		All	LMH	MHE
Harmonic voltage	LM	LMH	LMH	LMH	MHE	L	LM	MHE	All		All	LMH	MHE
Interharmonic voltage		LMH											
Mains signalling voltage		LMH		LMH									MHE
Single rapid voltage change		LMH	LMH					MHE	All	MHE		LMH	

Voltage dips are continuously monitored in almost all countries, which confirms that this is seen as an important issue. Supply voltage variations, flicker, voltage swells and harmonic voltage are continuously monitored in most countries. It is recommended that these disturbances are continuously monitored whenever technically and economically feasible.

Only a small number of countries continuously monitor the following voltage quality phenomena: power frequency, transient overvoltages, interharmonic voltage, mains signalling voltage and single rapid voltage changes. The need to monitor power frequency at many locations is limited as this is already continuously monitored by the TSO in every country as part of the operation of the system. However, with the proliferation of distributed generation in the future, both controlled and non-controlled island operation of parts of the system might become more common, so the need to continuously monitor power frequency will also increase.

For other disturbances (transient overvoltages, mains signalling voltage and single rapid voltage changes), there remains a lack of measurement methods in EN 61000-4-30 [31] or in any other internationally recognised document. The development of such measurement methods, including the definition of the characteristics, should get priority in international standardisation groups.

TABLE 3.12 | Initiatives for VQ monitoring and purposes (when not due to complaints)

Country	Initiative	Purposes
Austria	Other authorities.	Statistics
Bulgaria	-	-
Cyprus	TSOs	Statistics, regulation, research
Czech Republic	TSOs and DSOs	Statistics, regulation, research, network development
France	EHV/HV: TSOs MV: DSOs LV: Regulator, other authorities	Statistics, information to customers and to ensure that standards in legislation and contracts to individual customers are fulfilled
Greece	Regulator	Statistics
Hungary	Regulator	Statistics, competition by comparison
Italy	Regulator	Statistics, research, information, regulation, publication, definition of expected VQ levels
Latvia	DSOs	Statistics
Lithuania	TSOs and DSOs	Monitoring
The Netherlands	TSOs and DSOs	Statistics, regulation
Norway	Regulator	Statistics, regulation, monitoring
Portugal	Other authorities	Statistics, regulation
Romania	EHV: TSO and regulator HV, MV and LV: regulator	Statistics, regulation, research and development
Slovenia	Regulator and other authorities	Statistics, regulation, research and development

Table 3.12 shows the body that promoted the initiative for the monitoring scheme, for example the NRA, the Ministry, TSO(s) or DSO(s). The purposes of the monitoring are also reported.

In Italy, the voltage quality monitoring scheme at all voltage levels was initiated by the regulator with the following objectives:

- Statistics: knowledge and publication of statistical data;
- Information: improve the awareness of network users;
- Regulation: as a basis for possible future regulation and as a review of the existing technical rules; and
- Research: correlation analysis between voltage quality parameters and network characteristics, and investigation of the voltage impact of distributed generation in LV networks.

In Norway, the network companies are required to perform continuous monitoring of voltage quality in their networks in order to be able to:

- provide explanations for the historical quality performance of their networks;
- estimate the future quality in their networks; and
- provide the relevant voltage quality information requested by an individual customer (see Case study 6 for information provided to customers about past or expected future voltage quality levels in Norway).

Table 3.13 shows who bears the cost of voltage quality monitoring in the different countries. This includes the costs of the installation, maintenance and operation of the monitoring system.

Table 3.13 shows that pre-defined tariffs for voltage quality monitoring exist in only a small number of countries in Europe. In most countries, the TSO and/or DSOs pay for the costs of the monitoring scheme and recover these costs via their tariffs for network usage to all connected customers. The costs of global monitoring are therefore indirectly paid by all customers through the grid tariffs. Individual customers may request the measurement of the voltage quality at their connection point to the network at extra cost in some countries.

In France, customers may subscribe to optional service packages at an additional cost. Possible differences between the payments from customers (pre-defined tariffs) and the actual costs of monitoring are calculated into the standard grid tariffs.

TABLE 3.13 | Responsibility for voltage quality monitoring costs

Country	Pre-defined tariffs	Responsible for payment of costs of monitoring
Austria		DSOs, covered via grid tariffs to all connected customers
Bulgaria		DSOs, covered via grid tariffs to all connected customers
Cyprus		TSO, DSO and independent producers
Czech Republic		DSO, covered via grid tariffs to all connected customers
Finland		DSOs, covered via grid tariffs to all connected customers
France		All customers through grid tariffs
Greece		Regulator
Hungary		DSO
Italy		TSO, covered via transmission tariffs to all connected customers; National research funds for distribution voltage quality instruments; DSOs, covered via tariffs to all users (for LV smart meters).
Latvia	x	DSO
Lithuania	x	TSO / DSOs
The Netherlands		TSO / DSOs, covered via grid tariffs to all connected customers
Norway		TSO / DSOs
Portugal		TSO / DSO
Romania	x	TSO / DSO and wind power stations above 10 MW
Slovenia		TSO / DSOs, covered via grid tariffs to all connected customers

* Finland: No national monitoring programme is in place, but if an individual customer has a complaint, the DSO must monitor the voltage quality at its own cost (hence included in tariffs of all end-users).
* France: Monitoring of supply voltage variations only in the new type of smart meters currently being installed.
* Greece: The monitoring costs were paid from (1) the NRA's budget (which is financed through regulatory fees) and (2) the Greek ministry of development (tax payers' money and EU funds).

3.5.2 Smart meters and voltage quality monitoring

Some countries are planning to use smart meters to monitor voltage quality aspects alongside the measurement of the quantities of electricity consumed. To measure voltage quality aspects with smart meters, it is important to know whether the measurements are performed in accordance with international standards and/or good engineering practice. Otherwise, the measurements will be of limited value and their interpretation will in many cases be difficult.

Table 3.14 gives an overview of the countries in which smart meters are currently installed and to what extent these meters can monitor aspects of voltage quality.

TABLE 3.14 | Smart meters and voltage quality monitoring

Country	Smart meters?	Voltage quality monitoring possible?	Which parameters are (or can be) monitored?
Austria	Yes	Under analysis	At the moment, no nation-wide smart metering is in place, but a number of on-going projects with a discussion of functionality definition (e.g. supply voltage variations, unbalance).
Finland	Yes	Partly	Some smart meters can monitor supply voltage variations and voltage dips.
France	Yes	Partly	Supply voltage variations (from 10 minute intervals to 1 minute intervals).
Greece		Partly	Smart meters of MV customers can monitor voltage dips and swells.
Italy	Yes	Partly	Supply voltage variations.
Latvia	Yes	Partly	Supply voltage variations, voltage dips and swells, harmonic voltage.
Lithuania	Yes	Partly	Frequency, supply voltage variations.
The Netherlands	Yes	Partly	Supply voltage variations.
Portugal	Yes	No	No measurement of voltage quality parameters possible.
Sweden	Yes	Partly	Some smart meters can monitor supply voltage variations.

Table 3.14 shows that in most countries smart meters are able to measure supply voltage variations. Also, the measurement of voltage dips and swells by smart meters is fairly common.

In France, with the development of Automated Meter Management (AMM) systems, it will soon be possible to precisely monitor both interruptions and voltage variations on LV networks. For each LV customer, the date and the duration of (1) long interruptions, (2) short interruptions, (3) large voltage variations (i.e. 10-minute average above 110% or below 90% of the nominal voltage) will be automatically recorded and transmitted to the DSO. 250,000 experimental smart meters were already installed in 2010. The Government has validated the experimentation and from 2013/2014 smart meters will progressively replace old meters; 80% of customers should be equipped by 2020.

In Italy, all smart meters for LV customers (around 35 million, deployment rate about 95%) must be able to record and collect measurements relevant to supply voltage variations according to EN 50160. An initial monitoring campaign (involving more than 50,000 meters) was carried out in January 2010 at the regulator's request, when the preparation of the quality of supply regulation, to be enforced in 2012, was started. The question of how the future monitoring campaign shall be undertaken is under consultation (for instance, sample of about 1% of smart meters selected by the national regulator, information on the selected smart meters to be communicated to the DSOs 6 months in advance of the measurements, selection of 4 weeks including winter/summer peak and minimum load conditions).

In The Netherlands, the association of network operators Netbeheer Nederland has, in close cooperation with the TSO and DSOs and KEMA, 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 measurements of at least the magnitude of the supply voltage with all new smart meters for LV customers.

3.5.3 Indicators for voltage dips

Clear and consistent definitions of voltage dip indices are necessary in order to be able to interpret the results from measurement campaigns and to be able to effectively enforce limits. The calculation of voltage dip indices consists of 3 stages:

i. Calculation of the "dip characteristics" (also known as "single-event indices") from the sampled voltage waveform. This calculation is often performed by the monitoring instrument;
ii. Calculation of the "site indices", typically the number of dips per year with certain characteristics; and
iii. Calculation of the "system indices", for example the average number of dips per year per site.

Below, these 3 levels of indices will be discussed in more detail, including their definition in international standards and similar documents and the current practice in Europe.

3.5.3.1 Dip characteristics

The dip characteristics are calculated from the sampled voltage waveform. In most cases, this calculation takes place in the monitoring instrument and the user of the instrument cannot further influence this calculation. The resulting characteristics and indices depend strongly on whether the line-to-neutral or the line-to-line voltages are used as input to the calculation.

The following voltages are to be used according to EN 50160 [22]:

- On LV networks, for four-wire three-phase systems, the line-to-neutral voltages shall be considered;
- On LV networks, for three-wire three-phase systems the line-to-line voltages shall be considered;
- On LV networks, in the case of a single-phase connection, the supply voltage (line-to-line or line-to-neutral, according to the network user connection) shall be considered; and
- Typically, on MV and HV networks, the line-to-line voltages shall be considered.

The recommendations in CIGRE TB 412 [25] are along the same lines, where it is explained that using phase-to-phase voltages to obtain voltage dip statistics in MV and HV networks gives the most relevant information on voltage dips as experienced at the terminals of end-user equipment.

In some surveys, including some of the surveys of which the results are presented in this report, the phase-to-neutral voltages are used for MV and HV networks. This can have a significant impact on the voltage dip statistics. Earth faults in non-solidly earthed systems (a common practice in European countries) cause a low phase-to-neutral voltage whereas the phase-to-phase voltage only shows a minor drop in voltage, with the residual voltage often remaining above 90%. The end-user equipment will only experience the minor voltage drop. Using phase-to-neutral voltages will thus result in a significant overrepresentation of events due to earth faults in non-solidly earthed systems, which do not have a serious impact on end-user equipment.

But even for dips due to earth-faults in solidly earthed systems, measuring phase-to-neutral will result in an overestimation of the number of dips at the terminals of the end-user equipment. Due to the removal of the zero-sequence component, single-phase earth faults in HV or EHV networks will in the worst case result in a voltage dip with residual voltage down to 30%. In practice, such faults rarely result in dips with a residual voltage less than 40%. This does have an impact on the total number of dips, but it especially affects the number of dips with a duration of less than 200 milliseconds and a residual voltage less than 40% [37, Section 10.2.8]. The definition of major dips used in the forthcoming section thus excludes dips due to single-phase-to-ground faults in HV and EHV networks as well as in non-solidly-earthed MV networks.

Once the appropriate voltages have been sampled, the dip characteristics can be determined. 2 characteristics are defined in standard EN 61000-4-30 [31]:

- The residual voltagte is the lowest r.m.s. voltage [12] in any of the measurement channels during the event; and
- The duration of the voltage dip is the time during which the r.m.s. voltage is below a dip threshold in at least one of the measurement channels.

Most manufacturers of monitoring equipment have implemented these definitions and those in other standards. National regulation also refers to EN 50160 in most cases. The standard allows for some flexibility: the choice of the voltage dip threshold; and whether this threshold is a fixed percentage of a fixed voltage (the "declared voltage") or a fixed percentage of the voltage magnitude shortly before the event (the "sliding reference voltage"). It is common practice to use 90% of a reference voltage (often the nominal voltage) as a dip threshold. The standard EN 50160 states for LV, MV and HV: "Conventionally, the dip start threshold is equal to 90% of the nominal voltage." Thus, when monitoring is performed "in accordance with EN 50160", it should be assumed that this dip threshold has been used.

Recommendations by CIGRE TB 412 [25] and others suggest using a fixed dip threshold at LV and MV but a sliding reference at HV and EHV.

The definitions in EN 61000-4-30 do not distinguish between voltage dips in one, two or three phases. However, it is recommended in EN 50160 to "detect and store the number of phases affected by each event". Recommendations on how to treat dips in three-phase systems are given in CIGRE TB 412. According to these recommendations, a distinction is to be made between Type I, Type II and Type III dips, corresponding to the main voltage drop being in one, two or three phase-to-neutral voltages, respectively. The residual voltage for Type III dips is the same as the one according to EN 61000-4-30. For Type I and Type II voltage dips, somewhat different definitions of the residual voltage are proposed.

3.5.3.2 Site indices

From the voltage dips recorded at one location over a period of typically 1 year, site indices can be calculated. These are typically the number of voltage dips with characteristics within a certain range. According to EN 50160, voltage dips shall be classified using Table 3.15, below.

TABLE 3.15 | Classification of voltage dips according to the standard EN 50160

Residual Voltage u %	Duration t ms				
	$10 \le t \le 200$	$200 < t \le 500$	$500 < t \le 1{,}000$	$1{,}000 < t \le 5{,}000$	$5{,}000 < t \le 60{,}000$
$90 > u \ge 80$	CELL A1	CELL A2	CELL A3	CELL A4	CELL A5
$80 > u \ge 70$	CELL B1	CELL B2	CELL B3	CELL B4	CELL B5
$70 > u \ge 40$	CELL C1	CELL C2	CELL C3	CELL C4	CELL C5
$40 > u \ge 5$	CELL D1	CELL D2	CELL D3	CELL D4	CELL D5
$5 > u$	CELL X1	CELL X2	CELL X3	CELL X4	CELL X5

12. See the text of EN 61000-4-30 [31] for a definition of r.m.s. voltage.

For each of the cells in Table 3.15, the number of events per year is presented. To obtain this number of events, 2 levels of aggregation are needed: poly-phase aggregation (any difference in treatment for voltage dips in one, two and three phases); and time aggregation (any difference in treatment for multiple dips based on the time elapsed between these events).

According to EN 50160, poly-phase aggregation concerns the definition of an equivalent event characterised by a single duration and a single residual voltage. The general interpretation of this is that all voltage dips should be treated in the same way, independently of whether the voltage drop takes place in one, two or three phase-to-neutral voltages. However, the formulation in EN 50160 does not rule out the calculation of separate site indices for voltage dips affecting a different number of phase-to-neutral voltages.

Time aggregation remains a matter of disagreement and an issue that still has not been solved. In EN 50160 it is stated that "the method used for the aggregation of multiple events can be set according to the final use of the data"; further reference is made to IEC/TR 61000 2-8 [29]. Time aggregation is also discussed in CIGRE TB 261 [35] and CIGRE TB 412. From the information obtained by CEER, it has been concluded that no time aggregation is used in any of the surveys [13]. Thus, each voltage dip is counted even if it occurs shortly after another dip.

Instead of, or alongside the statistics according to the voltage dip table, other site indices can be calculated. This typically concerns the number of voltage dips per year more severe than the residual voltage and the duration according to a certain curve.

Case Study 11

Calculation of voltage dip indices for transmission networks in Italy

Under the Italian regulation, the number of voltage dips is monitored and publicly reported by the TSO for the voltage levels, 132-150 kV, 220 kV and 380 kV. Two site-indices are calculated:

- The number of dips per year with a residual voltage below 70% and a duration more than 500 ms, including interruption with a duration between 500 ms and 1 minute. In terms of Table 3.15 this corresponds to the following cells: C3, C4, C5, D3, D4, D5, X3, X4, and X5; and
- The total number of dips per year with a residual voltage below 90%. This corresponds to all cells in Table 3.15.

A distinction is made between events where only one phase-to-neutral voltage drops below 90% ("single-phase dips") and events where more than one phase-to-neutral voltage drops below 90% ("poly-phase dips"). For poly-phase dips the duration is determined for the phase with the lowest residual voltage.

The TSO annually sets thresholds for the number of single-phase and poly-phase dips (so called "expected voltage quality levels"). The 4 indices obtained from monitoring are compared with the thresholds. The NRA is not involved in the setting of these thresholds and there are no sanctions or penalties attached when the thresholds are exceeded.

13. Only in Italy (transmission), a minimum time of 0.1 second is indicated between different voltage dips.

Case Study 12

Proposed voltage dip indices for distribution networks in Italy

The Italian regulator recently proposed a number of voltage dip site indices to be used for distribution networks. 3 of the proposed indices are based on the counting of events:

- The total number of dips per year with a residual voltage below 90% (all cells in Table 3.15);
- The number of dips per year below a curve defined by the Class 2 testing levels in EN 61000-4-11 [30] and EN 61000-4-34 [41] (all cells except A1,A2,B1 and B2 in Table 3.15); and
- The number of dips per year below a curve defined by the Class 3 testing levels in EN 61000-4-11 and EN 61000-4-34 (all cells except A1, A2, A3, A4, B1, B2, and C1 in Table 3.15).

The "regulated dip-frequency index" is the average of the last 2 indices above.

Other site indices are based on defining a single dip characteristic that quantifies the severity for each individual voltage dip event based on its expected impact on customer installations and equipment in those installations. The site index is calculated as the sum of the severities for all events that occurred during 1 year. 3 different types of dip characteristics are proposed:

- The "discrete severity indices" compare the voltage drop with the voltage drop for a reference curve [14]; for a dip on the curve the value of the index is equal to 1, below the curve the value is higher than 1 as such a dip is more severe, above the curve the value is less than 1. 2 different reference curves are proposed, based on the Class 2 and Class 3 testing levels in EN 61000-4-11 and EN 61000-4-34.

- The "missing voltage time indices" calculate the severity of a voltage dip event as the product of the voltage drop and the duration. 3 options are proposed here: counting all dips; counting only dips below a curve defined by the Class 2 testing levels in EN 61000-4-11 and EN 61000-4-34; or counting only dips below a curve defined by the Class 3 testing levels in EN 61000-4-11 and EN 61000-4-34; and

- The "missing voltage time area indices" where the product of voltage drop and duration is divided by a reference value (100 pu.ms) and all events with a resulting value below 1 are not counted.

It is further proposed to use the average of the "regulated dip-frequency index" over all monitored sites as a system index and to present the results for individual sites as well as for the system as a whole in the form of voltage dip tables (as in Table 3.15, according to EN 50160) and as a contour chart [15].

3.5.3.3 System indices

When the site indices are available at a sufficient number of locations, so called "system indices" can be determined. The system indices can be the average of the site indices over all sites (with or without the use of weighting factors) or a percentile value of the site indices.

According to the recommendations given in CIGRE TB 412 [25] a number of percentile values should be used, for example the 25%, 50%, 75%, 90% and 95% values.

In France, as well as in Italy, both the averages over all sites and the 95% values are calculated. In Hungary and The Netherlands, only the averages over all sites are calculated.

3.5.4 Actual data on voltage dips

In this section, data reported by 5 countries (France, Hungary, Italy, The Netherlands and Portugal) is presented. In order to increase the comparability of the voltage quality data, only data for voltage dips has been included in this section. More specifically, this section focuses on major voltage dips, which

14. For more details see [24].
15. For a description of the contour chart see, among others, IEEE Std. 1346-1998 [34], CIGRE Report 261 [35], Section 2.4, and CIGRE Technical Brochure TB 412 [25], Chapter 6

will be defined below. A complete overview of the available voltage dip data and additional data concerning other voltage disturbances (for the above mentioned countries and for Slovenia) is reported in the Annex to Chapter 3 on Voltage Quality.

The concept of a "responsibility-sharing curve" was proposed in the European Energy Regulators' 2006-2007 voltage quality consultation paper [11]. Such a curve would distinguish between voltage dips for which regulation would be in place and voltage dips for which the owner of an installation would have to take measures. During the consultation, it was concluded that it was not yet possible to decide where such a curve should be located.

A possible choice for such a responsibility-sharing curve would be the preferred test levels and duration according to EN 61000-4-11 [30], for Class 3. These test levels and durations are:

- 40%, 200 milliseconds;
- 70%, 500 milliseconds;
- 80%, 5 seconds.

A possible responsibility sharing curve based on these values is shown in the Figure 3.3. The curve is close to equipment immunity Class C as proposed by CIGRE/CIRED/UIE joint working group C4.110 in CIGRE TB 412 [25], a recent proposal by the Italian regulator for the classification of voltage dips, and one of the curves used in the new Swedish regulation on voltage dips (see Case study 4 in Section 3.4.3 and Case study 11). The difference is that, according to the curve in Figure 3.3, the 80% border is extended all the way up to 1 minute.

Even without deciding on the need and the location of a responsibility sharing curve, an indicative curve can be used to distinguish between "minor dips" and "major dips", where the latter are the ones of most concern to the customer. In Table 3.16, the average number of major dips per location per year is given for those countries that provided data on voltage dips. Major dips are defined as dips below the indicative responsibility-sharing curve as defined in Figure 3.3.

The number of major dips presented in Table 3.16 has been obtained by summing the dips below the responsibility sharing curve and applying a normalisation factor consisting of the number of locations at which voltage dip measurements are performed and the monitoring duration at each measurement

FIGURE 3.3 | Indicative responsibility-sharing curve for voltage dips

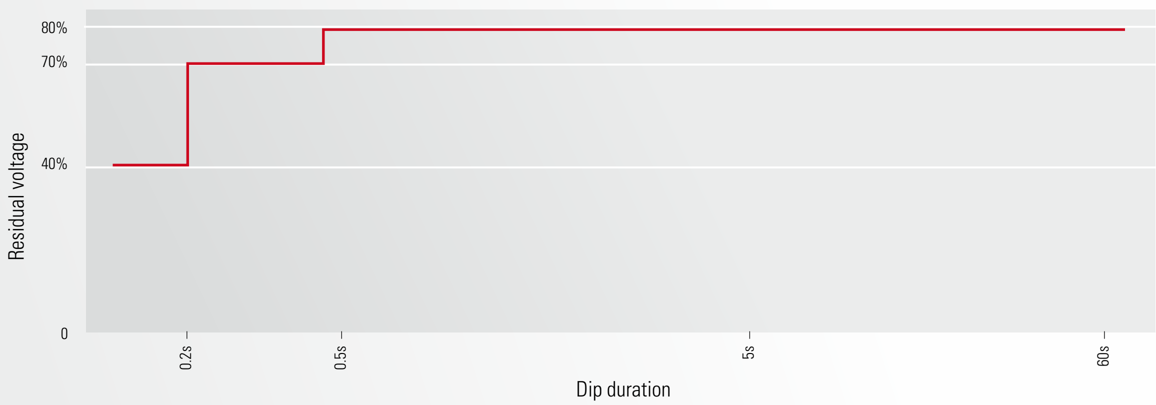


TABLE 3.16 | Number of major dips in different countries (events per monitor-year)

Country	2008	2009	2010
France (transmission)	2.1	2.5	1.7
Hungary (LV)		25.2	
Hungary (MV)		13.3	
Italy (MV)	26.6	18.8	15.9
The Netherlands (HV)	1.0	2.0	2.3
Portugal (HV)	18.7	15.3	

location. Table 3.16 therefore shows the average number of major dips per measurement location per year. The comparability of the number is thus only limited by the voltage level in which the measurements were performed and by the difference in network structure. Both of these factors have an impact on the expected number of voltage dips. It should also be noted that the table shows average number of dips over all measurement locations. The spread between individual locations is much larger.

Table 3.16 shows large differences in the number of major dips in the networks in the different reporting countries.

3.5.5 Publication of voltage quality data

In a number of countries, network operators are required to publish voltage quality data. In the 4th Benchmarking Report, an overview was shown of the kind of publications that network operators are required to produce. Table 3.17 shows that not much has changed in these legal requirements since the publication of the report in 2008.

TABLE 3.17 | Publication of voltage quality data

Country	Publicly available voltage quality data	Aggregated data available to regulator	Individual data available to regulator	Individual data available to end-users	Party responsible for publication	Method of publication
Austria	Yes	Yes	Yes	Yes	Regulator	First evaluation of data is in progress.
France	Yes	Yes		Yes	TSO / DSOs	The number of voltage dips in the transmission network is published in annual reports on the TSO's website.
Hungary	Yes	Yes	Yes		Regulator	Nationally aggregated data is published on the internet.
Ireland	Yes				TSO / DSOs	The DSO provides this information to the individual customer upon request about their own connection.
Italy	Yes	Yes	Yes		Italian electricity research centre / TSO	Aggregated data is published on the internet and in a TSO report.
The Netherlands	Yes	Yes		Yes	TSO / DSOs	Aggregated data for voltage quality measurements in all networks is published on the internet.
Norway	Yes	Yes	Yes	Yes	TSO / DSOs	All TSO/DSOs are required to provide data upon request by the individual customer. In addition, the TSO and some DSOs publish data on the internet.
Portugal	Yes	Yes	Yes	Yes	TSO / DSO	The TSO, DSO and regulator publish annual quality of service reports on their respective websites.
Slovenia	Yes	Yes	Yes	Yes	TSO / DSO / regulator	The TSO and DSO are required to publish voltage quality data. Aggregated data in an annual report is also available on the regulator's website.

Table 3.17 shows that for many countries in which voltage quality is monitored, at least some of the data obtained is publicly available. In addition, most regulators have access to at least aggregated data, if not to data for individual measuring points in the networks. In several countries, individual voltage quality data is also made available to customers. In most cases, the network operators (TSO and/or DSOs) are responsible for the publication of voltage quality data.

3.6 Findings and Recommendations on Voltage Quality

Finding #1
Voltage characteristics are regulated through EN 50160 in combination with stricter national requirements

Five years of cooperation between CEER and CENELEC led to the publication of a new version of the standard EN 50160:2010 [22], with a number of positive elements, discussed in Section 3.4.1. The CEER survey reveals that EN 50160 is used in many countries. But a growing number of countries are setting national requirements on voltage quality that deviate from EN 50160. In all cases, these requirements are stricter than those in EN 50160.

The impact of voltage quality disturbances on network users was further investigated by CEER in 2010, as described in Section 3.2. Guidelines of good practice were developed by CEER in the domain of nationwide studies on the estimation of costs due to voltage quality disturbances.

Recommendation #1A

Further improve EN 50160 as a harmonised instrument for voltage quality regulation

CEER retains the view that standard EN 50160 can be satisfactory from a regulatory point of view only if certain improvements are made. The main improvements needed are the following:

- An effective extension to the high voltage networks (with effective limits and requirements) and the consideration of extra high voltage networks;
- The adoption of new limits for supply voltage variations in distribution networks (especially in low voltage networks);
- The introduction of limits for voltage events, taking into account the different characteristics of the European networks; one or more responsibility-sharing curves should be defined for voltage dips and voltage swells; and
- A general framework for sharing the voltage quality responsibilities between network companies, equipment manufacturers and users.

Further, the need for proper regulation of voltage quality will increase in the future, taking account of the possible large-scale implementation of distributed generation.

CEER believes that harmonised voltage quality requirements are necessary. Unless the implementation of the above-mentioned improvements starts as soon as possible, standard EN 50160 will miss its objective to harmonise the voltage quality standards and performances across the European electricity networks, due to the fact that national deviations will increase further, as discussed in Section 3.4.3. Further strengthening of the voltage quality regulation in the individual countries, followed by attempts to harmonise this, would be the only alternative.

Recommendation #1B

Perform cost-estimation studies of voltage disturbances

The results from cost-estimation studies on customer costs due to various voltage quality disturbances are an important input when deciding where to focus regulation. Therefore, NRAs should perform national cost-estimation studies regarding voltage disturbances.

Finding #2
Verification of actual voltage quality levels at individual connection points is guaranteed in most of the countries

As discussed in Section 3.4.5, the network users in many European countries are entitled to receive a verification of actual voltage quality levels at their point of connection. Even in several countries where this is not compulsory, the network operators offer such verification. Still, this good practice is not adopted in all countries.

Further, the CEER survey reveals that increasing attention is being given to individual information to users on voltage quality at their point of connection (or close to it). This includes information for users to be connected. The introduction of smart meters with voltage quality monitoring capabilities could make it easier for customers to get access to the desired information on voltage quality.

Recommendation #2

Ensure individual voltage quality verification

The obligation for system operators to provide individual information on and verification of voltage quality upon user request should be adopted by all countries. This obligation should be accompanied by a detailed description of the procedure by the network operator so that all relevant information is available to the customer, including the cost of the service (if any).

It is further recommended that the regulator or the network operator keep statistics on complaints and verification results and correlate these with the results from continuous voltage quality monitoring (if in place).

Finding #3
Regulation of emission levels of network users varies across countries

A number of countries have regulated the emission requirements from individual network users (see Section 3.4.7). All but one use voltage limits or planning levels that should not be exceeded after connection. This could make it impossible or difficult to connect when the existing voltage distortion level is already high before connection. In most cases, reference is made to the indicative planning levels in IEC 61000-3-6 [38], 3-7 [40] and 3-13 [41]. In France, current limits are set, but these are also dependent on the short-circuit level. Connection could be difficult at locations with a low short-circuit level.

In a number of countries, penalties are foreseen for customers in case of violation of the maximum-permissible level of disturbance.

Recommendation #3

Set reasonable emission limits for network users

Limits on emission from individual customers are necessary to maintain the voltage disturbance levels below the voltage quality requirements without excessive costs for other customers. The limits on emission should be reasonable for both the network operator and the customers causing the emission. Unreasonable requirements should for example not result from low short-circuit levels. Whereas a margin between the planning levels and the voltage quality requirements is deemed good engineering practice, this margin should not be excessive.

Finding #4
Many countries have continuous voltage quality monitoring systems

Voltage quality monitoring systems were reported by more than half of the countries, details of these systems are presented in Section 3.5. The number of monitoring locations varies significantly between countries. Continuous monitoring is ongoing in 14 countries. This can be either under direct control of the regulator or compulsory but performed by the network operator. In some countries, the data is published, in other countries not.

In most countries, the network operator pays for the monitoring scheme and recovers these costs via the network tariffs for all customers. Individual customers may request the measurement of the voltage quality at the connection point at extra cost in some countries.

Another positive development is the increasing number of monitoring instruments in LV and MV networks, at the supply terminals or close to it. 5 of the 14 respondent countries with ongoing monitoring are addressing all voltage levels, 13 countries are addressing MV networks.

There is growing attention on the evaluation of voltage quality and its deviations through smart meters. 10 countries reported developments in this field: smart meters have the technical possibility to measure some voltage quality parameters (supply voltage variations in many cases, voltage dips and swells and harmonics in some cases).

Recommendation #4A

The scope of continuous voltage quality monitoring programmes should be broadened

CEER recommends that countries encourage network operators to continuously monitor voltage quality in their transmission and distribution networks. Monitoring should take place at locations such that a good estimation can be made of the voltage quality as experienced by the customers. It is further acknowledged that the data from continuous voltage quality monitoring can provide useful information for the network operator (see e.g. [33]) resulting in significant cost savings and information to support investment decisions.

The principle aims of compulsory or regulator-controlled monitoring should be: to verify compliance with voltage quality requirements (both overall and for individual customers); to provide information to customers on their actual or expected voltage quality; and to obtain information for the setting of appropriate future requirements. This should be considered when deciding on the need for compulsory or regulator-controlled monitoring.

Recommendation #4B

Exploit the possibilities offered by smart meters without excessive price increase for customers

With regard to smart meters, it is important to know whether the measurements are performed in accordance with international standards and/or good engineering practice or can only provide initial information about voltage deviations preliminarily to further measurements.

It is important to exploit the capabilities of available and installed smart meters to the extent and benefits possible but also to ensure that voltage quality monitoring through smart meters does not result in an excessive increase in the price of the meters or tariffs for the network users. The European Energy Regulators do not deem it necessary to monitor all voltage quality phenomena through smart meters for all LV users.

Finding #5

Differences exist between countries in the choice of monitored voltage quality parameters and in the reported voltage dip data

Although voltage quality monitoring takes place in several countries, the measured voltage quality parameters vary strongly from country to country, as shown in Section 3.5.1. Voltage dips are continuously monitored in almost all countries; this confirms that voltage dips are seen as an important issue. Supply voltage variations, flicker, voltage swells, voltage unbalance and harmonic voltage are continuously monitored in most countries. Transient overvoltage, single rapid voltage changes and mains signalling voltage are monitored in a small number of countries.

Actual levels of voltage dips have been reported by 5 countries (see Section 3.5.4). Here, some early trends towards harmonisation are reported, triggered by the latest edition of the standard EN 50160, with a new table for the classification of voltage dips and swells. The remaining differences in measurement methods, however, make a direct comparison of the results impossible. Even though both EN 50160 and international expert groups recommend measuring phase-to-phase voltages at MV, HV and EHV, this is not common practice. A systematic overview of measurement methods and voltage dip indices is presented in Section 3.5.3 of this report.

There remains a lack of standardised measurement methods for rapid voltage changes, transient overvoltage, and main signalling voltages.

Recommendation #5

Define harmonised characteristics and indices for voltage dips

When reporting the results from voltage dip monitoring, it is important to accurately define how characteristics (like residual voltage) and indices (like number of severe dips per year) are calculated. The voltage dip tables recommended in EN 50160 should be used to present the results from voltage dip monitoring.

When presenting and interpreting voltage dip indices, care should be taken not to mix short shallow dips with long deep dips, as both their impact on customer equipment and the mitigation measures required are significantly different. A distinction between major and minor dips, as in Section 3.5.4, in combination with the voltage dip tables recommended in EN 50160, is a possible approach.

System indices should include not only the average number of dips per site per year, but also values not exceeded at a certain percentage of sites. These so-called percentiles give a better impression of the actual voltage quality as experienced by individual customers than the average number of dips alone.

Finding #6

Voltage quality data is publicly available in some European countries

For many countries in which voltage quality is monitored, at least some of the data obtained is publicly available, as discussed in Section 3.5.5. In addition, most regulators have access to at least aggregated data, if not to data for individual measuring points in the networks. In several countries, individual voltage quality data is also made available to end-users. In most cases, the network operators (TSO and/or DSOs) are responsible for the publication of voltage quality data.

With increasing numbers of monitors, the amount of available voltage quality data also increases quickly. However, resources available to network operators and/or regulators to analyse all of this data are limited.

Recommendation #6

Ensure availability and regular publication of voltage quality data

CEER recommends that countries that monitor voltage quality in their transmission and distribution networks publish results regularly. It is also strongly suggested to store as much data as feasible for several years, including raw data, where possible in an easily-accessible format to allow future queries that cannot be foreseen yet.

It is suggested that the data from compulsory or regulator-controlled monitoring is made available, as far as appropriate, for research and educational purposes. This includes - among other things - a better understanding of the changes in voltage quality parameters related to the introduction of new types of generation and consumption. A mechanism should be in place to prevent the data from being used against the network operators, for example by not identifying the exact measurement location. The results of such research must be made publicly available without undue delay.

4.

Commercial Quality

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

In a liberalised electricity market, the customer concludes either a single contract with the supplier (SP) or separate contracts with the supplier and the distribution system operator (DSO), according to the existing national regulations. In both cases, however, commercial quality is an important issue.

Commercial quality is directly associated to 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 or expected by customers, such as new connections, increase of the connection capacity, disconnection upon customer's request, meter reading and verification, repairs and elimination of voltage quality problems, answering phone calls, etc. Each of these services mentioned above is a transaction that involves some commercial quality aspect. The most frequent commercial quality aspect is the timeliness of services requested by customers. However, the definition of the term 'timeliness' may vary from country to country.

Where it concerns the need for commercial quality standards, a distinction between the deregulated market of electrical energy and the regulated market of network operation should be made. The energy regulator normally does not intervene in the deregulated market as competition between retailers is expected to result in the sufficient quality. However, in some cases, a certain level of customer protection is needed. Such protection can be provided through standards. The need for such protection differs among different types of customers, where small domestic customers most likely need more protection.

Network operators (i.e. the regulated market) possess a natural monopoly, free or almost free from competition. To ensure a sufficient level of quality, a set of Guaranteed Standards (GSs) and Overall Standards (OSs) are needed. Another debated aspect is the incentive regulation for revenues of network operators. This price-regulation method (price/revenue cap, price formula and pricing period) provides the network companies with strong incentives to reduce their overall costs – this accounts also for operational expenditures and capital expenditures – in order to increase efficiency. A reduction of operational expenditures may result in a decline of the actual quality levels of network services or, at the very least, result 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 ei-

ther 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. Here, the involvement of customers and their representatives can make an important contribution to quality regulation; customer surveys can reveal both customer expectations and satisfaction with the current level of service as well as appropriateness of the regulation already in place.

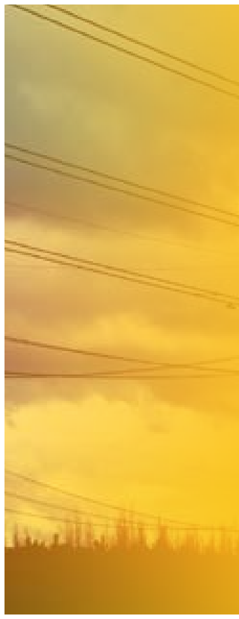
There is also a question as to whether it is appropriate to maintain minimum standards with regard to supply when competition is fully developed, such that companies compete in providing services and performances which exceed these minimums. The fact is that some commercial quality aspects (e.g. times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

Last but not least, an important call for regulation of commercial quality arises from the new EU legislative measures. Indeed, Directive 2009/72/EC [27] requires that Member States shall take appropriate measures to protect final customers, to ensure that they:

- Have a right to a contract with their electricity service provider that specifies:
  - the services provided, the service quality levels offered, as well as the time for the initial connection;
  - any compensation and the refund arrangements which apply if contracted service quality levels are not met, including inaccurate and delayed billing;
  - information relating to customer rights, including on the complaint handling and all of the information referred to in this point, clearly communicated through billing or the electricity undertaking's website.
- Benefit from transparent, simple and inexpensive procedures for dealing with their complaints. In particular, all customers shall have the right to a good standard of service and complaint handling by their electricity service provider.

4.2 Main Conclusions from Past Activities of the European Energy Regulators on Commercial Quality

The chapter on commercial quality has been an integral part of all Benchmarking Reports of CEER so far. According to the definitions in the 1st Benchmarking Report (2001) [1] commercial quality concerns the quality of relationships between a supplier and a user. In this relationship, it is also very important that the potential customer should have the correct data regarding the conditions of network connection even before using the service. It was obvious while drafting the 1st Benchmarking Report that commercial quality includes such a broad range of services that only some of them could be regulated based on the usual standards and measuring methodologies. The definitions of OS and GS were introduced for categorisation of the regulatory methods. The elemental difference between the 2 types of standards is the reimbursement for the customer that is peculiar to the GS, when the standard is not fulfilled. The internal questionnaire which was prepared for the 1st Benchmarking Report was completed by 6 countries, as a result the evaluation and the processing of the data did not cause significant difficulties. The evaluated 25 standards were organised around some concrete topics (e.g. access to the network, investigation of problems and complaints and communication personally, by phone or in writing). 4 countries out of 6 applied both types of standards, 1 country used only GSs and another 1 used individual standards without any compensation. The number of standards applied as guaranteed ranged between 6 and 11 in each single country and overall was between 1 and 9 in each single country. The values of the 7 most frequent GSs were evaluated one by one. The scale of compensation (15-33€) – to be paid automatically or by request in case of non-fulfilling the standards – was also presented.



A question arose during the preparation of the 2nd Benchmarking Report (2003) [2]: whether market liberalisation would make commercial quality regulation unnecessary. The questionnaire included 6 questions about this issue. The answers provided by the respondents on the latter issue raised the necessity of unbundling the regulations for the DSO and supplier. The Benchmarking Report points out that the number of regulations for suppliers has decreased in countries with fully opened markets but it forecasts the opposite for the DSO. 10 countries answered the questionnaire. The questionnaire was aimed to survey actual data in order to provide the authors with the chance to make an international comparison. Due to country specificity of the data, this goal unfortunately could not be fully reached. The definitions of overall and guaranteed standards were determined as they are used nowadays. The in-coming answers showed that many countries were already using the standards. There were 4 countries where the number of OSs and GSs together was above 15. From the 25 standards that were involved in the survey, there were 9 which were applied in more than 5 countries. In most of the countries, the compensation was paid automatically.

The 3rd Benchmarking Report (2005) [3] aimed to measure the actual state of the regulation as widely as possible. The CEER questionnaire originally listed 24 standards and also allowed countries to specify any additional standards specific to them. As a result, 19 countries provided data for altogether 48 standards and there were also data for the actual level of application of 42 standards. The 14 most frequently used standards were evaluated in 5 groups. This survey involved the evaluation of data of Transmission System Operators (TSOs) for the first time. In respect of OS / GS and compensation to be paid automatically or by request, there was a rate shift in favour of GSs and the compensation to be paid automatically. Furthermore, it was concluded that the regulatory authorities closely followed the level of the services provided to customers, still with significantly different sets of standards with different contents and implementation levels. The need for clarifying all specific indicators (e.g. how times are calculated) was highlighted. Also, CEER recommended that countries put in place GSs together with compensation to be paid automatically to the customer, where appropriate.

The wide list of standards led to a more focused approach when preparing the 4th Benchmarking Report [4] (2008). CEER adjusted the list of most common standards, by reformulating the names of some standards and including a new standard about "Time from notice-to-pay until disconnection". 15 standards that were found as the most frequently used in 21 countries were evaluated in 4 groups. It was obvious that the majority (approx. 80%) of the regulations were related to the DSO. In addition to the two types of standards of the previous Benchmarking Reports, a new one was introduced, i.e. Other Available Requirements (OAR, see Section 4.4.3), as a form of regulation and it has become the most frequently used standard type. The payment of the compensation is performed upon request in the majority of the 9 responding countries. The questionnaire involved a new question-group in order to survey the full market opening regulation. Due to its novelty, the evaluation of the scarce data did not provide a representative result. In the communication between the licensee and the customer, as well as in the method of gathering the measured data, a wider use of mobile phones and e-mail as well as the advantages provided by the smart meters also emerged. CEER acknowledged that regulations concerning these new issues were still in their infancy.

In the 4th Benchmarking Report, CEER recommended that:

- Countries consider the usefulness of GSs tied to direct automatic compensation for non-compliance with the quality parameters or other regulatory requirements with the possibility to impose sanctions, wherever information on the particular parameter makes it possible;
- National Regulatory Authorities (NRAs) consider developing procedures capable of measuring the performance of call centres and monitor the performance of the licensees in order to establish regulations.

The European Energy Regulators assessed in the recent years one important aspect of commercial quality - the treatment of customer complaints. The Guidelines of Good Practice (GGP) on customer complaint handling, reporting and classification [8] were published in 2010. The proposal of consumer complaints classification included as a first-level classification quality of supply issues, which is further broken down into continuity of supply complaints or voltage quality complaints as a second-level classification. The Status Review on implementation of the GGP on customer complaints (2011) [9] includes an overview of existing statutory complaint handling standards and recommendations on how to set up these standards.

4.3 Structure of the Chapter on Commercial Quality

Taking into account the distinction between the deregulated market of electrical energy and the regulated market of network operation, the current 5th Benchmarking Report is more focused on commercial performance of the DSOs and less on commercial performance in the competitive sector of supply as compared to the past Benchmarking Reports. Due to this focus and to other ongoing activities of the European Energy Regulators, the impact of market opening on commercial quality is not discussed in this edition.

The 5th Benchmarking Report adopts the same approach as the 4th Benchmarking Report. First, it discusses the main aspects of commercial quality and categorises standards into four groups (see Section 4.4.1), then it provides the list of standards which were surveyed (see Section 4.4.2) and the approaches for regulating commercial quality (see Section 4.4.3).

The contents of this chapter on commercial quality are based on answers provided by 18 CEER countries[16]: Austria, the Czech Republic, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, The Netherlands, Norway, Portugal, the Slovak Republic, Slovenia, Spain, Sweden and the United Kingdom[17]. In addition, Denmark indicated that the regulator does not set commercial quality standards. Germany provided some additional information without any detailed data. The results of the benchmarking are presented in Section 4.5, organised by main groups of commercial quality aspects. Attention is paid to the level of compensation to the customers (see Section 4.5.6).

For the first time, historical data for the 3-year period (2008-2010) since the 4th Benchmarking Report was surveyed. The actual data is presented in Section 4.6. Lastly, a summary of the benchmarking results is provided in Section 4.7.

4.4 Main Aspects of Commercial Quality

Commercial transactions between electricity companies and customers 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 by both 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 customers' queries, complaints and claims, or repairs. 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 the DSO, the supplier, to the Universal Supplier (USP)[18] or to the meter operator (MO) and could be regulated according to the regulatory framework of the particular country.

A recurring dilemma is the question of which customer class (voltage level) the regulation should focus on. In the 4th Benchmarking Report, beyond low voltage[19] (LV), some respondents also supplied commercial quality data related to customers connected at medium voltage (MV) and high voltage (HV). As requirements set for MV and HV are considerably different from those at LV, the comparison did not result in useful information. For this reason, this chapter focuses on residential customers with a connection to the LV network because while this is the largest group of customers at the same time they have a small economic potential. However, all replies are shown in detail in the Annex to Chapter 4 on Commercial Quality.

4.4.1 Main groups of commercial quality aspects

In order to simplify the approach to such a complex matter as commercial quality, indicators relating to commercial quality have been classified into 4 main groups:
- Connection (Group I);
- Customer Care (Group II);
- Technical Service (Group III);
- Metering and Billing (Group IV).

4.4.2 Commercial quality standards and their definitions

Based on the list of the most commonly used standards and recommendations from past CEER activities on commercial quality (3rd and 4th Benchmarking Reports), a questionnaire was prepared with precise specifications towards the comparability of

16. There is a country whose data - due to delayed data provision – is not considered in the analysis, but can be found in the Part 1 of the Annex to Chapter 4.
17. The United Kingdom's answers refer to Great Britain.
18. Universal suppliers exist in some countries in order to supply domestic and small customers who do not choose a supplier in the free market or who rely on their supplier of last resort (in cases when the supplier fails to supply electricity for a variety of reasons).
19. See Section 2.4.3 for the CEER classification of voltage levels.

the data. At the same time, from a logical point of view, some realignments were made among standards of the connection (Group I) and customer care (Group II) groups. One standard was divided into 2: (1) "time for answering the voltage complaint"; and (2) "time between the date of the answer to the voltage complaint and the elimination of the problem".

In addition to that, 2 new standards (1) "time for disconnection upon customer's request"; and (2) "time until the restoration of supply in case of unplanned interruption" were included. Table 4.1 shows the commercial quality standards which are surveyed in CEER countries and the definitions elaborated in the process of preparing of the 5th Benchmarking Report.

TABLE 4.1 | Commercial quality standards surveyed

Group	Standard	Definition
I. Connection	I.1 Time for response to customer claim for network connection	Time period between the receipt of customer's written claim for connection and the written response of Licensee (date of dispatch), if no intervention is necessary on the public network
	I.2 Time for cost estimation for simple works	Time period between the receipt of customer's written claim for connection and the written response of Licensee including a cost estimation of works (date of dispatch), if connection can be executed by simple works
	I.3 Time for connecting new customers to the network	Time period between the receipt of customer's written claim for connection and the date the customer is connected to network, if no intervention is required in the network
	I.4 Time for disconnection upon customer's request	Time period between the receipt of customer's written request for disconnection (de-activation) until the date the customer is disconnected. See also de-activation of supply
II. Customer Care	II.5 Punctuality of appointments with customers	The personnel of Licensee appears on the customer site within the time range (period of hours) previously agreed with the customer
	II.6 Response time to customer complaints and enquiries (including 6a and 6b)	Time period between the registration of a customer complaint or enquiry and the date of the response to it
	II.6a Time for answering the voltage complaint	Time period between the registration of a customer complaint or enquiry and the date of the response to it (including on-site measurement and investigation)
	II.6b Time for answering the interruption complaint	Time period between the registration of a customer complaint or enquiry and the date of the response to it, also including history and justification of interruptions
	II.7 Response time to questions in relation to costs and payments (excluding connection)	Time period between the receipt of customer's questions (excluding cost estimation for connection) and the answer to it
III. Technical Service	III.8 Time between the date of the answer to the VQ complaint and the elimination of the problem	Time period between the answer to the complaint and the elimination of the voltage disturbance
	III.9 Time until the start of the restoration of supply following failure of fuse of DSO	Time period between the failure of a DSO fuse and the start of fuse repairs
	III.10 Time for giving information in advance of a planned interruption	Time period between the advance notice of a planned interruption and the beginning of the planned interruption
	III.11 Time until the restoration of supply in case of unplanned interruption	Time period between the beginning of an unplanned interruption and the restoration of supply to the individual customer affected
IV. Metering and Billing	IV.12 Time for meter inspection in case of meter failure	Time period between the meter problem notified by the customer and the inspection of the meter
	IV.13 Time from notice to pay until disconnection	Time period between the notice to pay / notice of disconnection after missing payments and the disconnection of the customer
	IV.14 Time for restoration of power supply following disconnection due to non-payment	Time period between the payment of debts by the customer and the restoration of supply to the customer
	IV.15 Yearly number of meter readings by the designated company	The number of actually performed meter readings by the designated meter operator (readings by the customer are excluded)

The main results of the benchmarking are described in Section 4.5 distinguishing between the 4 main groups.

4.4.3 How to regulate commercial quality

There are 2 main and 2 supplementary types of requirements (hereafter they are often called 'standards') for commercial quality:

- **Guaranteed Standards** (GSs) refer to service quality levels which must be met in each individual case. If the company fails to provide the level of service required by the GS, it must compensate the customer affected, subject to certain exemptions. The definition of GSs includes the following features:
  - performance covered by the standards (e.g. estimation of the costs for the connection);
  - maximum time before execution of the performance - commonly determined in terms of response (fulfilment) time (e.g. 5 working days);
  - economic compensation to be paid to the customer in case of failure to comply with the requirements.
- **Overall Standards** (OSs) refer to a given set of cases (e.g. 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 are defined as follows:
  - performance covered (e.g. connection of a new customer to the network);
  - minimum level of performance (commonly in % of cases), which has to be met in a given period (e.g. in a 90% of new customers have to be connected to the distribution network within 20 working days).
- **Other Available Requirements** (OARs). In addition to GSs and Oss, regulators (and/or other competent parties) can issue requirements in order to achieve a certain quality level of service. These quality levels can be set as the regulator wants, 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, the regulator can impose sanctions (e.g. financial penalties) in most of the cases.
- **Only Monitoring** (OMs). Before issuing GSs and OSs, regulators (and/or other competent parties) can monitor performances of DSOs, suppliers, universal suppliers and metering operators, in order to understand the actual quality level and to publish - when deemed appropriate - the actual data on services provided to the customers.

4.5 Main Results of Benchmarking Commercial Quality Standards

4.5.1 Commercial quality standards applied

Responses are included in Table 4.2, in accordance with the survey structure.

Table 4.2[20] shows whether a country monitors and/or applies a requirement (GS, OS or OAR) for the different commercial quality aspects. In the last column, the total number of countries where a standard is in effect is shown. The most common standards among the regulators are the ones concerning connection (Group I) and customer care (Group II) issues. It is important to mention that 16 responding countries apply some type of standard regarding the time for connecting customers to the network (standard I.3, see Table 4.2).

In Table 4.3, the number of various commercial quality standards is shown together with the type of company they refer to (DSO, supplier, USP and MO). The largest number of standards is in force for connection (Group I) and customer care (Group II).

Table 4.4 shows the number of commercial quality standards per country, distinguishing between GSs, OSs OARs and OMs. It is evident 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 in case of non-compliance. From the customer protection point of view, the most efficient regulation is based on GSs, or minimum requirements set by the regulator where sanctions can be issued. The practice in CEER countries with advanced commercial quality regulation shows that OSs have been decreasing in number while increasingly more GSs have come into force over time. This process is likely to continue in other countries in the near future as well. Although it is difficult to compare the data with the results of the 4th Benchmarking Report (because of

20. The differences in the total number of standards in Tables 4.2, 4.3, 4.4 and 4.17 are due to the fact that in the questionnaire some countries did not indicate the type of the standard (GS, OS and etc.) or the type of company it refers to. In some cases, the same standard is applied as a GS and an OS and refers to the DSO and the supplier at the same time. As a result, the aggregation of standards based on different aspects lead to different total values in the tables.

the different set of responding countries), it is possible to conclude that the number of GSs increased. Simultaneously, the number of OSs and OARs decreased.

TABLE 4.2 | Summary of countries which adopt commercial quality standards

Group	Standard	AT	CZ	EE	FI	FR	GB	GR	HU	IE	IT	NL	NO	PT	SK	SI	ES	SE	Total
I. CONNECTION	I.1 Time for response to customer claim for network connection	✓	✓	✓	✓		✓	✓	✓				✓		✓	✓	✓		11
	I.2 Time for cost estimation for simple works	✓		✓	✓	✓	*	✓	✓	✓	✓	✓	✓	✓		✓	✓		14
	I.3 Time for connecting new customers to the network	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		16
	I.4 Time for disconnection upon customer's request			✓	✓	✓				✓	✓		✓						6
II. CUSTOMER CARE	II.5 Punctuality of appointments with customers		✓	✓		✓	✓		✓	✓	✓	✓	✓	✓		✓			11
	II.6 Response time to customer complaints and enquiries (including 6a and 6b)			✓	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓		11
	II.6a Time for answering the voltage complaint		✓	✓	✓		✓		✓			✓	✓	✓	✓	✓	✓		11
	II.6b Time for answering the interruption complaint			✓	✓							✓	✓	✓		✓	✓		7
	II.7 Response time to questions in relation to costs and payments (excluding connection)		✓	✓	✓						✓	✓	✓		✓	✓	✓		9
III. TECHNICAL SERVICE	III.8 Time between the date of the answer to the VQ complaint and the elimination of the problem		✓	*	✓				✓	✓	2		✓						6
	III.9 Time until the start of the restoration of supply following failure of fuse of DSO		✓	*	✓		✓		✓	✓	✓		✓	✓		✓			10
	III.10 Time for giving information in advance of a planned interruption	✓	*	✓	✓		✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	14
	III.11 Time until the restoration of supply in case of unplanned interruption		✓	✓	✓		*		✓	✓	✓	✓	✓	✓	✓	✓		✓	13
IV. METERING AND BILLING	IV.12 Time for meter inspection in case of meter failure		✓	✓	✓				✓	✓	✓	✓			✓	✓			9
	IV.13 Time from notice to pay until disconnection	✓		✓	✓	*							✓			✓		✓	7
	IV.14 Time for restoration of power supply following disconnection due to non-payment	✓	✓	✓	✓				✓	✓	✓		✓	✓	✓	✓			11
	IV.15 Yearly number of meter readings by the designated company	✓		✓	✓	✓			✓	✓	✓	✓	✓	✓		✓		✓	12
Total number of countries with standard in effect		**7**	**11**	**17**	**16**	**7**	**9**	**3**	**13**	**11**	**12**	**11**	**16**	**10**	**8**	**15**	**8**	**4**	**178**

Note: * means that the type of requirement (GS, OS, OAR or OM) is not specified. * are counted in the totals.
Note: 2 means that the standard is introduced in 2012. It is not counted in totals.
Note: one country is not counted in the totals. See Part 1 of the Annex to Chapter 4 for more details.

The Czech Republic, Great Britain and Ireland use GSs. Other countries (Finland, Greece, The Netherlands, Norway and the Slovak Republic) tend to mostly use OARs. In Estonia, the regulator monitors a set of requirements and sets OSs. Hungary and Italy make use of all the three types of standards (GSs, OSs, OARs) with a larger adoption of GSs.

TABLE 4.3 | Number of commercial quality standards (GS, OS, OAR, OM) in force per group and per company type

STANDARD		DSO	SP	USP	MO	Total
I.1	Time for response to customer claim for network connection	13				13
I.2	Time for cost estimation for simple works	17				17
I.3	Time for connecting new customers to the network	19				19
I.4	Time for disconnection upon customer's request	7				7
II.5	Punctuality of appointments with customers	12				12
II.6	Response time to customer complaints and enquiries	13	4	1		18
II.6a	Time for answering the voltage complaint	12				12
II.6b	Time for answering the interruption complaint	7		1		8
II.7	Response time to questions in relation to costs and payments (excluding connection)	8	2			10
III.8	Time between the date of the answer to the VQ complaint and the elimination of the problem	6				6
III.9	Time until the start of the restoration of supply following failure of fuse of DSO	10				10
III.10	Time for giving information in advance of a planned interruption	14				14
III.11	Time until the restoration of supply in case of unplanned interruption	16				16
IV.12	Time for meter inspection in case of meter failure	8			3	11
IV.13	Time from notice to pay until disconnection	7	1			8
IV.14	Time for restoration of power supply following disconnection due to non-payment	10	2		1	13
IV.15	Yearly number of meter readings by the designated company	11			3	14
Total		**190**	**9**	**2**	**7**	**208**

TABLE 4.4 | Number of commercial quality standards surveyed, per country and per type of requirement

COUNTRY	GS	OS	OAR	OM	TOTAL
AUSTRIA		7			7
CZECH REPUBLIC	10				11
ESTONIA		14		5	22
FINLAND			16		16
FRANCE	2	1		3	7
GREAT BRITAIN	7				9
GREECE			6		6
HUNGARY	14	2	4		20
IRELAND	7			4	11
ITALY	13	2	2		17
THE NETHERLANDS	2		12		15
NORWAY			16		16
PORTUGAL	9	5			14
SLOVAK REPUBLIC			8		8
SLOVENIA	8		7		15
SPAIN	7	1			8
SWEDEN	1		5		6
Total	**80**	**32**	**76**	**12**	**208**

Note: the total in the last column includes also 8 national standards, whose type (GS, OS, OAR, OM) is not specified. Therefore, the total value (for CZ, EE, FR, GB, NL) is different than the sum of the other columns.

Note: one country is not counted in the totals. See Part 1 of the Annex to Chapter 4 for more details.

4.5.2 Group I: Connection

This group concerns commercial quality standards that are applicable only to DSOs and are applied by a large number of regulators. The reason for this is two-fold. On the one hand, both speedy clarification of the network access conditions and timeliness of concrete connections are of high priority to customers. On the other hand, connection is mainly related to distribution and is therefore strictly related to the regulation of a monopoly activity (although in a few countries this activity can be performed by independent companies).

Table 4.5 contains data for household customer connections to the LV network: countries are grouped by the type of applied standards, descriptive values of the standards and compensation. Several countries provided data for standards for customers connected to different voltage levels (MV or HV), which are included in the Annex to Chapter 4 on Commercial Quality.

Table 4.5 shows a synthesis of the commercial quality standards for connection-related activities. It is important to point out some particularities:

- As connection-related activities are closely interrelated, some countries reported that the standards are not entirely identical with the ones they apply. For example, in Hungary the indicators I.1 ("Time for response to customer claim for network connection") and I.2 ("Time for cost estimation for simple works") are identical and there is no option (by law) for disconnection upon the customer's request. In Italy, the reply to a customer claim for connection is treated either as an "activation of supply without interventions outside the meter" (I.3) or as a "cost estimation of works" if interventions and works are needed (I.2). In Portugal: (1) there is no standard corresponding to "time for response to customer claim for network connection" (I.1); (2) there is, however, a standard for "time for construction of new connection for LV customers"; (3) over the past three years, actual performance levels have been relatively stable and are on average approximately 98% with 8.5 working days; (4) all the characteristics of this standard are the same as for "time for cost estimation for simple works" (I.2);
- Standards for connection-related activities often have a complex structure, depending upon the complexity of the work to be done. This may be a reason why some countries could not tell under which type of standard their requirement falls. The differences in interpreting what "complex work" means probably explain why a considerably broad range of standards' and compensations' values can be observed (see Table 4.7); and
- Compensation in case of non-compliance with the guaranteed standards can also have a complex structure. In many countries, compensation depends upon voltage level or the type of customer (household or business customer). In Italy, for instance, compensation in 2010 is 30€ for domestic customers, 60€ for business LV customers and 120€ for business MV customers.

TABLE 4.5 | Commercial quality standards for connection-related activities

Quality indicator (Group I)	Countries (grouped by type of Standard)				Standards (median value and range)	Compensation (median value and range)	Company Involved
	GS	OAR	OS	OM			
I.1 Time for response to customer claim for network connection	CZ, GB, HU, SI, ES	FI, EL, HU, NO, SK	AT, EE		16 days (range 8-30)	27€ (range 18-50)	DSO
I.2 Time for cost estimation for simple works	FR, HU, IE, IT, ES	FI, EL, HU, NL, NO, SI	AT, EE, PT		14 days (range 5-35)	30€ (range 18-30)	DSO
I.3 Time for connecting new customers to the network	CZ, GB, HU, IE, IT, ES	FI, EL, HU, NL, NO, SK, SI	AT, PT	EE, FR	11 days (range 2 working days - 18 weeks)	40€ (range 18-250)	DSO
I.4 Time for disconnection upon customer's request	IT	FI, NO	EE	FR, IE	5 working days (range 5-8)	Only one country 30€	DSO

The requirements for indicators of Group I have been defined according to different criteria. In some countries, the expected level of quality is determined by the voltage level, in others by the connection capacity or the complexity of the project. The diversity of regulation is clearly shown in Tables 4.6 and 4.7.

TABLE 4.6 | Examples of criteria by which the standard I.2 "Time for cost estimation for simple works" and compensation can be distinguished

Country	Criteria	Obligation
GREAT BRITAIN	Single LV service demand connection	5 working days
	A small project demand connection	15 working days
	In other cases	25 days
IRELAND	No visit to site is required	7 working days
	A visit to site is required	15 working days
	Larger developments or >100 kW or in MV	90 working days
ITALY	Automatic compensation doubles	after 40 working days
	Automatic compensation triples	after 60 working days
SPAIN	Supplies <15 kW (LV)	5 days
	Other without Substation investment (LV)	10 days
	Other supplies with Substation investment (LV)	20-30 days
	1-66 kV	40 days
	> 66 kV	60 days

TABLE 4.7 | Examples of criteria by which the standard I.3 "Time for connecting new customers to the network" and compensation can be distinguished

Country	Criteria	Obligation/Compensation
CZECH REPUBLIC	LV	5 working days/ € 250-2,500
	MV, HV	5 working days/ € 500-5,000
FRANCE	Date agreed with the customer	-----
GREAT BRITAIN	LV	25 working days
	HV	35 working days
	EHV	65 working days
IRELAND	In 2 weeks after receiving the receipt of the Electro Technical Council of Ireland Completion Certificate and if the connection is paid at least 10 weeks prior to the completion of the electrical installation	2 weeks
ITALY	Other types of connection, which include works, are subject to two different standards	Different standards

Answers for the standards I.2 and I.3 (see Part 2 of the Annex to Chapter 4, tables A4.2.2 and A4.2.3) show the variation of the average performance time in the years 2008 to 2010. The average time for cost estimation for simple works does not exceed 10 days in the majority of countries and shows a decreasing trend between 2008 and 2010. The average performance time of 1.13 days in Hungary is due to the fact that the cost of simple works is determined in the law, therefore providing information regarding this issue does not require detailed analysis.

4.5.3 Group II: Customer care

While the standards in Group I (connection) refer exclusively to DSOs, in Group II the standards apply mostly to DSOs but also to suppliers. Also for the standards in Group II, some responding countries have indicated that certain standards cannot be unambiguously interpreted. For example, in Hungary, indicators II.6 ("Response time to customer complaints and enquiries (including 6a and 6b)") and II.7 ("Response time to questions in relation to costs and payments (excluding connection)") are considered to be identical, and there is no separation of customer complaints and enquiries from questions related to costs and payments.

In Slovenia, some recommendations such as II.5 ("Punctuality of appointments with customers") (OS: 2 hours, 95%), II.6a ("Time for answering the voltage complaint") (OS: 30 working days, 90%), II.7 ("Response time to questions in relation with costs and payments (excluding connection)") (GS: 8 working days) came into force in 2011.

A very important issue is that of appointments with customers. Some operations (for example, access to the premises) require the presence of the customer. Regulators can impose standards (mainly GSs for DSOs) in order to ensure punctuality of appointments with customers. As shown in Table 4.8, many countries apply standards for this quality aspect. In addition, compensations when the standard is not met are due in almost all responding countries. The level of the compensation payments for this quality aspect is very much alike in all responding countries.

The most developed area for standards traditionally relates to answering customer letters (contacts in writing). In addition, in some countries the customer contact between suppliers or DSOs and customers implies customer service through call centres (the number of which is considerably higher than that of the contacts in writing) and customer personal visits to customer centres. The latter is expected to be the highest quality level service.

Table 4.9 shows some examples for requirements in the call and customer centres. As in both cases only short contact with dialogue are established the aim of all regulations is to cut the customers' waiting time wasted prior to the dialogue. An option to achieve prior mentioned aim would be the setting of average maximum waiting time. Other practices prefer to require a percentage of minimum waiting times versus the total number of cases.

TABLE 4.8 | Commercial quality standards for customer care related activities

Quality indicator (Group II)	Countries (grouped by type of Standard)				Standards (median value and range)	Compensation (median value and range)	Company Involved
	GS	OAR	OS	OM			
II.5 Punctuality of appointments with customers	CZ, FR, GB, HU, IE, IT, PT	NL, NO, SI	EE		2.5 hours (range 0.5-4)	24€ (range 18-100)	DSO, SP
II.6 Response time to customer complaints and enquiries (including 6a and 6b)	GB, HU, IT, SI, ES	FI, NL, NO	EE, FR, HU, IT, PT		15 days (range 5-40)	20€ (range 18-30)	DSO, SP
II.6a Time for answering the voltage complaint	CZ, GB, HU, PT, SI, ES	FI, NL, NO, SK	EE		18 days (range 5-60)	22€ (range 18-50)	DSO
II.6b Time for answering the interruption complaint	PT, SI, ES	FI, NL, NO	EE		15 days (range 7-21)	Only one country 30€	DSO
II.7 Response time to questions in relation to costs and payments (excluding connection)	CZ, SI	FI, NO, NL, SK	EE, IT, ES	EE	13 days (range 5-40)	Only two countries (range 25-30)	DSO, SP

TABLE 4.9 | Examples for the regulation of customer contacts other than in writing

Country	Call centres' average holding time	Call centres' service level	Waiting time in case of personal visit at customer centres
ESTONIA	OM for DSOs and SPs. Requirement: 25 sec, actual value in 2010 is 34 sec.	OM for DSOs and SPs. Requirement: 80 % of calls shall be answered within 25 sec. Actual value in 2010 is 85 %.	
HUNGARY	OS for DSOs and USPs. Requirement: 20 sec, actual value in 2010 is 18.86 sec.	OS for DSOs and USPs. Requirement: 75 and 80 % of calls respectively, shall be answered within 30 sec. Actual value in 2010 is 80.2 and 81.3 % respectively.	OS for DSOs and USPs. Requirement: maximum waiting time is 20 min in 90 % of cases. Actual values in 2010 are 87.6 and 87.9 % respectively.
ITALY	OS for DSOs and USPs. Requirement: 240 sec, actual value in 2010 is 135.63 sec.	OS for USPs. Requirement: 80 % of calls shall be answered. Actual value in 2010 is 91.8 %.	
PORTUGAL		OS for DSOs and USPs. Requirement: 85 % of calls shall be answered within 60 sec. Actual value in 2010 is 96.1 and 92.2 % respectively.	OS for DSOs and USPs. Requirement: maximum waiting time is 20 min in 90 % of cases. Actual values in 2010 are 95.5 and 94.0 % respectively.

The data in Table 4.9 indicates a relative low number of countries applying regulations for the customer contacts other than in writing. Therefore, as mobile ways of communication are growing, regulators – in order to protect customer interests – should put more emphasis on regulations aiming to shorten the time spent in such call and customer centres.

4.5.4 Group III: Technical service

Group III includes indicators that are related to technical service (III.8 to III.11, see first column of Table 4.10). All indicators relate to distribution activities, therefore the standards of Group III exclusively refer to DSOs.

Coping with voltage complaints normally involves 2 steps. The first step in the remedy of voltage complaints is to verify, through performing measurements, whether any regulation or norm in force has 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 complaint related to voltage disturbance is rectified without undue delay. 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 will depend upon the complexity of the given situation. Standard III.8 "Time between the date of the answer to the VQ complaint and the elimination of the problem" is new, compared to the 4th Benchmarking Report. As briefed in Section 4.4.2, the aim of the question on voltage quality in the 4th Benchmarking Report was to evaluate the regulations in relation to the first step of solving the problem (customer complaint – measurements – verify the problem – response to the customer), while in the 5th Benchmarking Report the requirements for both steps (response to the customer (see standard II.6.a) – correction of the voltage problem) are investigated. Only the Czech Republic, Hungary and Ireland reported existing numerical GSs (See Table A4.1.8). Italy is introducing a guaranteed standard in 2012. Finland and Norway did not give specific deadlines: in these countries the problem has to be solved within a reasonable time period.

One of the most commonly applied indicators of Group III is the time until the start of the restoration of supply following failure of a fuse of the DSO (III.9, see Table A4.1.9). In some countries (the Czech Republic, Hungary and Portugal), this standard depends on the customer's geographic location, the voltage level, the time of the call (day or night) and on whether the customer possesses any electronic medical device needed for survival. It is interesting to note that in Portugal, if a fuse failure is caused by the customer, compensation may have to be paid to the DSO.

TABLE 4.10 | Commercial quality standards for technical customer service

Quality indicator (Group III)	Countries (grouped by type of Standard)			Standards (median value and range)	Compensation (median value and range)	Company Involved
	GS	OAR	OS			
III.8 Time between the date of the answer to the VQ complaint and the elimination of the problem	CZ, HU, IE, IT (2012)	FI, NO		6 months (range 1- 24)	50€ (range 18-50)	DSO
III.9 Time until the start of the restoration of supply following failure of fuse of DSO	CZ, GB, HU, IE, IT, PT, SI	FI, NO		4 hours (range 3-24)	30€ (range 18-50)	DSO
III.10 Time for giving information in advance of a planned interruption	GB, HU, IE, SI, ES	FI, IT, SK, NL, NO	AT, EE, SE	2 days (range 1-15)	22€ (range 18-30)	DSO
III.11 Time until the restoration of supply in case of unplanned interruption	CZ, HU, IE, IT, NL, SE	FI, NO, SK, SI	EE, PT, SE	12 hours (range 1-24)	30€ (range 18-100)	DSO

TABLE 4.11 | Examples of criteria by which the standard III.9 "Time until the start of the restoration of supply following failure of fuse of DSO" and compensation can be distinguished

Country	Criteria	Obligation/Compensation
CZECH REPUBLIC	In Prague	4 hours
	Elsewhere	6 hours
HUNGARY	More than 50,000 inhabitants, on week days	4 hours
	More than 50,000 inhabitants, on weekends and between 5,000 and 50,000 inhabitants, on working days	6 hours
	Between 5,000 and 50,000 inhabitants, at weekends and less than 5,000, on working days	8 hours
	Less than 5,000 inhabitants, at weekends and on the periphery of municipalities	12 hours
	On periphery of municipalities	12 hours
ITALY	Automatic compensation doubles after double standard time	
	Automatic compensation triples after triple standard time	
PORTUGAL	For customers dependent on medical equipment	3 hours
	In areas classified as "C" (rural areas)	5 hours
	In other cases	4 hours

The time of giving information on the planned interruption (III.10, see Table A4.1.10) is used as an indicator by 13 reporting countries. The aim of notifying a customer about 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 types of customers, i.e. industrial versus residential. The negative consequences of an interruption will also vary a lot between the groups of type of customers. In almost all responding countries some requirements for a deadline have been applied. In a few countries (the Czech Republic, Hungary and Slovakia), the deadline for providing customers with information on planned interruptions is very long (15 days). In contrast to that, in most of the other countries a deadline between 1 and 2 days is applied. In a few cases, this deadline differs depending on the type of work requiring the planned interruption or the affected voltage level. Despite the importance to customers of being informed about planned interruptions ahead of time, only 3 countries apply compensation in the case of non-fulfilment.

Time until the restoration of supply in case of unplanned interruptions (III.11, see Table A4.1.11) is used as an indicator by 13 reporting countries. As expected, standards are diverse and depend on the voltage level and the location of the interruption. For further details, please refer to Table 4.10 and to the relevant tables in the Annex to Chapter 4 on Commercial Quality.

In some countries, the parameters of standard III.9 ("Time until the start of the restoration of supply following failure of fuse of DSO") have been determined according to some features of the city in question (e.g. number of inhabitants or type of settlement), as shown in Table 4.11.

As the restoration of supply is a complex process, the parameters used for standard III.11 ("Time until the restoration of supply in case of unplanned interruption") differ among responding countries (see Table 4.12 below).

4.5.5 Group IV: Metering and billing

Group IV includes a set of commercial quality indicators related to metering and billing (IV.12 to IV.15, see first column of Table 4.13). Table 4.13 summarises responses on commercial quality indicators of Group IV that refer mainly to DSOs. Suppliers are regulated in Hungary and monitored in Estonia. In several countries (such as Estonia, Italy and The Netherlands), the standards are also set for MOs.

In general, only a few regulators have set standards relating to metering. Regarding the duration of an inspection of a meter failure (IV.12), the typical standards in use are relatively heterogeneous. It is interesting to note that all the 4 types of requirements are used. Compensation in case of non-performance is applied in a small number of responding countries.

Standards for the time from notice to pay until disconnection (IV.13) typically vary between 1 and 2 weeks. Furthermore, there are several examples where NRAs apply country-specific (geographic or other) considerations. Such country-specific regulations are used in Finland, where it is indicated that: "*…the provision of network service to a building or a part of a building used as a permanent residence may not be interrupted because of default on payment between the beginning of October and the end of April, if the building is heated by electricity, before four months have elapsed since the due date of the outstanding payment*." If the default in payment is being caused by financial difficulties that the user has run into because of a severe illness, unemployment or some other special cause, principally through no fault of his/her own, the network service may be interrupted at the earliest 3 months after the due date of the payment. The user shall notify the DSO of the reason for the non-payment as soon as he/she is aware of it and, if possible, before the due date of the invoice. Here, the provision of network service to the customer or residential property may not be interrupted if the outstanding invoice to the customer amounts to less than 200€ or if less than 3 months have elapsed since the due date of the oldest outstanding invoice. If the customer's default on payment is due to force majeure, the provision of network service may not be interrupted as long as it prevails. In Hungary, disconnec-

TABLE 4.12 | Examples of the criteria by which the standard III.11 "Time until the restoration of supply in case of unplanned interruption" and compensation can be distinguished

Country	Criteria	Obligation
CZECH REPUBLIC	In Prague, LV	12 hours
	LV	18 hours
	In Prague MV, HV	8 hours
	MV, HV	12 hours
HUNGARY	In case of a single interruption	12 hours
	In case of multiple simultaneous interruptions	18 hours
	Compensation doubles	after 24 hours
	Compensation triples	after 36 hours
SLOVAK REPUBLIC	< 1 kV	24 hours
	> 1 kV	18 hours
SLOVENIA	85% of customers	3 hours
	100% of customers	24 hours

tion is allowed only after 60 days from the due date of payment and only if within this period 2 notices have been sent to the customer. Compensation for this commercial quality indicator is not commonly used in the responding countries.

The standard regarding the time to restore the power supply following disconnection due to non-payment (IV.14) attracted the most attention among the responding NRAs. This standard is closely linked to the availability of the service. Customers who have settled their debts and paid all fees in connection with the disconnection can request to be reconnected to the electricity network 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.

In half of the reporting countries, reconnection of customers must be performed by the DSO within a (working) day. NRAs intend to incentivise DSOs to complete the reconnection as soon as possible through a burden of paying an increasing amount of compensation (see Table 4.14).

The statements in the 4th Benchmarking Report concerning typical values for the maximum time between meter readings (IV.15) have become somewhat out-dated since smart meters are being installed in many countries. Therefore, spectacular differences are reported by the responding countries, from one reading every 3 years to daily data collection. Therefore, the median value in Table 4.13 should be treated carefully.

TABLE 4.13 | Commercial quality standards for metering and billing (household, LV only)

Quality indicator (Group IV)	Countries (grouped by type of Standard)				Standards (median value and range)	Compensation (median value and range)	Company
	GS	OAR	OS	OM			
IV.12 Time for meter inspection in case of meter failure	CZ, HU, IT	FI, NL, SK, SI	EE	IE	10.5 days (range 3-30)	25€ (range 18-30)	DSO, MO
IV.13 Time from notice to pay until disconnection	SI	FI, NO	AT, EE, SE		15 days (range 8-28)	NA	DSO
IV.14 Time for restoration of power supply following disconnection due to non-payment	CZ, HU, IT, PT	FI, NO, SK, SI	AT	EE, IE	(range 1 day-8 working days)	30€ (range 18-50)	DSO, SP, MO
IV.15 Yearly number of meter readings by the designated company	PT	FI, HU, IT, NL, NO, SI	AT, SE	EE, FR, IE	1 per year (range 0.33-365)	NA	DSO, MO

TABLE 4.14 | Examples of the criteria by which the standard IV.14 "Time for restoration of power supply following disconnection due to non-payment" and compensation can be distinguished

Country	Criteria	Obligation/Compensation
CZECH REPUBLIC	LV	2 working days / 50-1,250€
	MV, HV	2 working days / 150-3,750€
ITALY	Automatic compensation doubles (LV, MV)	After 2 working days
	Automatic compensation triples (LV, MV)	After 3 working days
PORTUGAL	LV	Until 5 pm next day
	MV, HV	8 hours

TABLE 4.15 | Compensations due if commercial quality guaranteed standards are not fulfilled

Country	Payment method		Execution of payment		
	Automatic	Upon Claim	Cheque	Discount in bill	Bilateral agreement
AUSTRIA					X
CZECH REPUBLIC		X			
FRANCE		X			
GREAT BRITAIN			X		
HUNGARY	X		X		
ITALY	X			X	
THE NETHERLANDS	X			X	
PORTUGAL	X				
SPAIN				X	

4.5.6 Compensations to customers

Table 4.15 shows that there is a great variety of payment methods in case of compensations to customers when GSs are not fulfilled in the reporting countries. Standards can be classified by the type of payment, as shown in Table 4.15.

Automatic compensation, or other available regulatory requirements where sanctions can be issued, is preferable in order to guarantee effective customer protection. Detailed information on the amount of compensation is available later in this chapter, as well as in Part 1 of the Annex to Chapter 4. This amount can vary, according to each CEER country, by the customer sector (residential or not), or by the voltage level (LV, MV etc.) or depending upon the delay in executing the transaction beyond the standard. In Italy, the automatic compensation doubles and triples when the actual time of the performance is more than two times or three times the time set by the standard, respectively. Compensation sums in the Czech Republic are among the highest ones across the CEER countries.

In general, it can be concluded that penalties are not frequently used. In Hungary, the standards named OARs are set in the law; therefore any penalty may only be applied subsequent to a public administration procedure.

4.6 Actual Levels of Commercial Quality

There are 2 ways to monitor the actual level of commercial quality:

- Monitoring the average value of the indicator, for instance the average time for making a new connection; and
- Monitoring the percentage of cases in which the company complies with the standard set by the regulator, i.e. the actual performance time is below (or above) the standard.

It is important to note that the first way of measuring the actual quality level does not depend upon the standards and is therefore comparable between countries (assuming that requirements of the same type are considered). In contrast, the second way of measuring, also called *compliance percentage*, is not meaningful without knowing the standard to which it refers.

In the 4th Benchmarking Report, insufficient data was provided on the actual performance levels of the quality standards, therefore cross-country comparisons were not feasible. For the 5th Benchmarking Report, respondents were asked for the first time to report data for the period 2008 – 2010, therefore the option appeared to analyse the effectiveness of the regulation in the time period. A larger amount of information became available for the current Benchmarking Report, possibly due to the regulators' growing attention to commercial quality standards. Altogether, 10 countries reported commercial quality data, which are presented in Part 2 of the Annex to Chapter 4. In Table 4.16, only a small selection of indicators from each of the 4 main groups is shown. It is essential to note that analysis based on data from a period of 3 years or less may lead to misleading conclusions. In order to give a general overview on the progress different countries have made, we applied averages within each main group. The figures were calculated by averaging the non-compliance figures within the main group. Although the values are not weighted by the (otherwise subjective) importance of the questions included in the groups, it still provides a reliable impression of the direction of improvement.

The growing number of countries collecting data is encouraging. Table 4.16 shows that Estonia, France and the Slovak Republic have recently started collecting data on commercial quality aspects.

Concerning connection performance standards, most countries made noticeable progress in the past few years. For all countries, the non-compliance percentage was below 10 % during 2010. If looking at the countries that provided full set of answers (data for all the 4 groups and for all the 3 years), one of the biggest leaps occurred in Hungary where the overall performance indicator shows an improvement of 6%. This improvement is mainly due to improvements of the standards "Time for response to customer claim for network connection" (I.1) and "Time for cost estimation for simple works" (I.2), as indicated in Tables A4.2.2[21] and A4.2.3. Still there is room for improvement in the "Time for connecting new customers to the network" (I.3). Despite the differing data available in the 3 years surveyed, it can be concluded that the overall tendency is clearly positive.

Actual performance for the standard "Time for connecting new customers to the network" (I.3) varies significantly between countries (see Table A4.2.3) and there is no clear trend visible. The average of 93 days in Estonia is significantly higher than the average of less than 5 days in most of the countries. In France, the same standard (I.3) only includes new buildings that are connected to the grid for the first time, which is the reason for the quite high average performance time of 39 days. The performance time for newcomers in buildings that were already connected to the grid is below 5 days for 96% of the connections. In terms of connecting new customers to the network, Italy is reporting a good performance for its LV users (see Table A4.2.3). This is associated to at least 2 aspects: first, the activity covered by this standard is the connection of new network users (activation of new supplies) with interventions on the meter (i.e. without works, either simple or complex on the network side, for which separate standards and statistics are in use). Second, in Italy the roll-out of smart meters for LV users is very close to completion. In most cases, the performance "activation of a new supply" can be delivered to the customer through the smart metering system, therefore leading to a significant reduction of time needed for it.

Similarly to connection (Group I), the reported indicators are also quite low in all countries for the customer care (Group II), see Table 4.16. Only the indicators from Greece and Great Britain in 2009 show non-performances of more than 20%. The overall picture is relatively homogeneous with large

TABLE 4.16 | Average non-compliance percentage by countries

COUNTRY	I. Connection			II. Customer care			III. Technical service			IV. Metering and billing		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
CZECH REPUBLIC	0.20	0.55	0.30	1.95	2.75	1.13	5.90	4.93	4.10			0.05
ESTONIA			0.50			0.00			0.65			8.90
FRANCE			9.57			1.70						5.75
GREAT BRITAIN				7.00	22.00	0.00	55.00	41.00				
GREECE	18.30	8.29			24.52							
HUNGARY	11.78	8.73	5.31	8.79	6.84	6.41	0.62	0.45	0.61	6.25	3.52	1.72
IRELAND	5.00	8.00	5.00							12.17	13.67	12.00
ITALY	5.15	1.12	0.23	0.70	0.60	6.64	1.20	0.90	0.90	1.45	1.10	0.80
PORTUGAL	0.56	0.75	0.56	2.95	2.42	1.05	2.43	4.68	3.72		0.72	0.31
SLOVAK REPUBLIC		5.20	2.50		8.60	0.50		0.90	0.30		1.15	0.10
TOTAL	**6.83**	**4.66**	**3.00**	**4.28**	**9.68**	**2.91**	**13.03**	**8.81**	**1.71**	**6.62**	**4.03**	**3.70**

21. Tables entitled "A4.x.x.x" correspond to the tables contained in the Annex to Chapter 4.

differences observed only for Italy and the Slovak Republic between the 2009 and 2010 indicator values. Italy saw a deterioration (rise from 0.6% to 6.64% non-compliance) whereas the Slovak Republic saw constant improvement (from 8.6% to 0.5% non-compliance).

The data on the average performance time of response to customer complaints and enquiries in years between 2008 and 2010 (see Part 2 of the Annex to Chapter 4) clearly show that although the performance of DSOs and USPs/suppliers is different in responding countries, customers will receive a response to their notice within an average of 15 days. In Portugal, the average response time to customer enquiries in 2010 – 0.46 days for the DSOs and 0.26 days for the USPs (see Table A4.2.6) – is very low because not only written enquiries but also all the phone enquiries (which are usually answered immediately or later in the same day) are considered. The average response time to customer complaints in 2010 was 8.0 days for the USPs and 8.5 days for the DSOs.

The indicators of technical service (Group III) remained either about the same or improved slightly in every reporting country during the period of 2008 – 2010, see Table 4.16 and Tables A4.2.8 to A4.2.11 for details. The great improvement in performance of technical service in 2010 is mostly due to the inclusion of Estonia with a low non-compliance value (0.65% in 2010).

Table 4.16 shows that performance indicators for metering and billing (Group IV) are the least monitored commercial quality standards. Where historical data is available, slight improvements in performance can be identified. Hopefully, more countries will be monitoring and reporting their performance levels, so that more thorough analyses can be performed in the future.

We would like to note again that the average performance should not be compared across countries, the only purpose of it is to provide a view into the actual levels of commercial quality, at a glance. Numbers of cases and average performance times can be seen in Part 2 of the Annex to Chapter 4 where the data is available.

4.7 Summary of Benchmarking Results

Tables 4.17 and 4.18 synthesise results in terms of applied standards (see also Section 4.5.1). Standards for DSOs are the largest part of the total: 190 out of 208 national standards. Table 4.17 shows the number of countries where the listed commercial quality standards are in force for the DSOs per type of standard (GS, OS, OAR or OM).

According to Table 4.17, the average number of standards whose type is specified is 12.25 [standards/activity] in the connection (Group I). This figure is the highest among the other groups (see below), meaning that connection to the network in the CEER countries is of primary importance. The figure would be even higher if it referred only to standards I.1 ("Time for response to customer claim for network connection"), I.2 ("Time for cost estimation for simple works") and I.3 ("Time for connecting new customers to the network") without counting I.4 "Time for disconnection upon customer's request" (which was introduced as a new commercial quality performance in this benchmarking report).

Customer care (Group II) (with an average value of 10.0 standards/activity), technical service (Group III) (with an average value of 9.8 standards/activity) and metering and billing (Group IV) (with an average value of 9.0 standards/activity) are more or less regulated to the same extent. It can be noticed that great attention is paid to the quickest possible restoration of supply irrespective of whether loss of supply was caused by faults, missing payments and information on notice for planned interruptions. This confirms the priority in regulation to ensuring the availability of supply. One may assume there is a relation between strong or weak regulation and the importance of the activities in that group. Proof of this may be the subject of future investigations.

Furthermore, as sign of prospective development of regulation, the presence of 10 OMs is promising considering a likely introduction of new standards in the close future.

Looking at the average number of standards per activity group, there is a considerable difference between them. OSs are more frequently applied for regulation of customer care (Group II) issues than in the case of the other 3 groups of activities. In some important cases GSs, OSs and OARs are used in parallel by the CEER countries.

TABLE 4.17 | Number of countries where commercial quality standards are in force (per type of standard, referring only to activities of DSOs)

Standard	GS	OS	OAR	OM	TOTAL
I. CONNECTION					
I.1 Time for response to customer claim for network connection	5	2	5		11
I.2 Time for cost estimation for simple works	5	3	6		14
I.3 Time for connecting new customers to the network	6	2	7	2	16
I.4 Time for disconnection upon customer's request	1	1	2	2	6
TOTAL FOR CONNECTION INDICATORS	17	8	20	4	47
II. CUSTOMER CARE					
II.5 Punctuality of appointments with customers	7	1	3		11
II.6 Response time to customer complaints and enquiries	5	5	3		11
II.6a Time for answering the voltage complaint	6	1	4		11
II.6b Time for answering the interruption complaint	3	1	3		7
II.7 Response time to questions in relation to costs and payments (excluding connection)	2	2	4		8
TOTAL FOR CUSTOMER CARE INDICATORS	23	10	17	0	48
III. TECHNICAL SERVICE					
III.8 Time between the date of the answer to the VQ complaint and the elimination of the problem	3		2		6
III.9 Time until the start of the restoration of supply following failure of fuse of DSO	7		2		10
III.10 Time for giving information in advance of a planned interruption	5	2	6		14
III.11 Time until the restoration of supply in case of unplanned interruption	6	2	4		13
TOTAL FOR TECHNICAL SERVICE INDICATORS	21	4	14	0	43
IV. METERING AND BILLING					
IV.12 Time for meter inspection in case of meter failure	2	1	4	1	8
IV.13 Time from notice to pay until disconnection	1	2	3		7
IV.14 Time for restoration of power supply following disconnection due to non-payment	3	1	4	2	10
IV.15 Yearly number of meter readings by the designated company	1	1	7	3	11
TOTAL FOR METERING AND BILLING INDICATORS	7	5	18	6	36
TOTAL	**68**	**27**	**69**	**10**	**174**

Note: the last column gives the number of countries in which a least one standard for DSOs is in force. As the type of 8 national standards is not specified and as one country can have a combination of different types (e.g. GS and OS), the last column is not necessarily the sum of the other columns.

Table 4.18 shows the standards applied in the CEER countries, per group of indicators and per type of standard (GS, OS, OAR or OM). The reader is also referred also to Table 4.4 for the overview of the use of different standard types country by country.

TABLE 4.18 | Commercial quality standards applied by the CEER countries per type of standard and question groups

Country	I. Connection				II. Customer care				III. Technical service				IV. Metering and billing			
	GS	OS	OAR	OM	GS	OS	OAR	OM	GS	OS	OAR	OM	GS	OS	OAR	OM
AUSTRIA		X								X				X		
CZECH REPUBLIC	X				X				X				X			
ESTONIA		X		X		X		X		X				X		X
FINLAND			X				X				X				X	
FRANCE	X			X	X	X										X
GREAT BRITAIN	X				X				X							
GREECE			X					X								
HUNGARY	X		X		X	X			X				X		X	
IRELAND	X			X	X				X							X
ITALY	X				X	X			X		X		X		X	
THE NETHERLANDS			X				X		X		X				X	
NORWAY			X				X				X				X	
PORTUGAL		X			X	X			X	X			X			
SLOVAK REPUBLIC			X				X				X				X	
SLOVENIA	X		X		X		X		X		X		X		X	
SPAIN	X				X	X			X							
SWEDEN									X	X				X		
TOTAL	**8**	**3**	**7**	**3**	**9**	**6**	**5**	**2**	**10**	**4**	**6**	**0**	**5**	**3**	**7**	**3**

4.8 Findings and Recommendations on Commercial Quality

Finding #1
There is a widespread use of commercial quality standards in European countries

Based on the data received from CEER countries, the first finding is the generally acknowledged principle of the need to regulate commercial quality. As indicated in Tables 4.3 and 4.4, 17 responding countries reported 208 national commercial quality standards attached to 15 performances requested by customers. This confirms the fact that European countries and regulators devote great attention to the quality of services provided to customers. Although the set of activities regulated, as well as the character and the expected goals of regulations, are similar, there remain individual regulations (like "within reasonable time", or "unless bilateral agreement") that have the same role but are less easily enforced than standards.

The regulation of a given activity and a given target quality level can be achieved in many ways and by the use of various standards. The quality regulations discussed in this chapter serve as hints, samples or as sources for ideas. Regulators should find the most applicable regulation for their specific national, cultural, political and economic circumstances. In order to lay the foundation of future regulation, some countries are already using indicators only for monitoring.

Theoretically, there are many ways to classify customers served by DSOs and suppliers. Type of settlement (rural, urban), type of consumption, or type of connection capacity are the mostly used categories. Still, the most commonly used (and technically the easiest to implement) classification is by voltage level as there are significant differences in design and operation of LV, MV and HV networks. The difference in the amount of consumption is also important for commercial quality. As the data reveals, regulatory authorities – acknowledging these specific features – either set standards by voltage levels or, while doing this, focus only on LV and thus on domestic and other small customers.

Recommendation #1

Periodically review the national regulations of commercial quality

It is indeed important to have a periodic review of the commercial quality standards, taking into account the development of national conditions (e.g. the retail market opening, the availability of technological developments such as smart meters) and - most importantly - the expectations of the customers. Monitoring the actual level of commercial quality (average values of the indicators and percentages of fulfilment) has an important role in such periodic reviews. The most important factor in this process is the availability of ample and realistic data. In order to provide these, it is inevitable to use the OM option, especially if its aim is to substantiate future regulation of a so far unregulated activity.

Care should be taken concerning the establishment and selection of the possible minimum number of standards otherwise the large number of those may burden the data analysis and evaluation, and may induce unnecessary expenses for the operators, together with an unwanted increase in tariffs.

It is recommended to treat separately the actual performances for MV and HV customers, in order to avoid a distortion effect to the median value.

Finding #2
There is a trend for increasing the adoption of GSs

The data collected shows that in general commercial quality indicators can be used by regulators in 3 ways:

- To define OSs, either without any economic consequence for the DSO or supplier upon non-compliance or including economic sanctions. Regulators are entitled to impose sanctions like fines or reducing tariffs;
- To set GSs by which customers receive direct compensation if standards are not met; or
- To apply OAR and in case of non-compliance sanctions can be imposed by the regulator.

The analysis for this Report confirms that there is a general trend over time to move from OSs to GSs, which was already identified by the 4th Benchmarking Report. The survey reports 80 GSs in force, compared to 32 OSs.

In countries where competition works properly, the regulatory authorities engage themselves in the surveillance of DSOs' activities in a much greater proportion than in respect of suppliers' activities. This is confirmed by the number of standards used in the countries: 190 standards for DSOs, 11 for suppliers and USP.

Recommendation #2

Enforce GSs in order to protect customers better

It is recommended that regulators should apply GSs with automatic compensation or OSs or OARs associated with the option of sanctioning. For the most important connection (Group I) standards, a combination of OS with economic sanctions and GSs is recommended, in order both to improve the average performances and to protect customers from worst service conditions.

This recommendation is especially applicable for the case of DSOs. With regard to services by suppliers, where markets work properly and efficiently, CEER believes that only few regulations would be needed in the long run.

Finding #3
Priority of having access to electricity

The survey clearly shows that priority is given to the standards for connection of new customers to the network (I.1 – I.3 in Table 4.2) or for minimising the amount of time that existing customers are interrupted (III.9 and III.11 in Table 4.2) and also to minimising the inconvenience of interruptions (III.10 in Table 4.2). CEER supports this priority ranking, as it aims at the maximum possible availability of electricity supply and matches well the expectations of the customers.

Recommendation #3

Properly prioritise the national regulations of commercial quality

CEER recommends countries and their regulators to assess customer priorities before creating new regulatory framework accordingly.

Finding #4
There are proven opportunities of high tech developments for improving quality for customers

Having accurate billing, based on actual, measured consumption is becoming more and more important both for customers and licensees. All parties may expect a more detailed picture of consumption habits (profiles) on the basis of which they would be able to plan network maintenance, energy purchases or eventual changes in the daily consumption practices. Recognising this need, many countries have launched programmes aiming at collecting monthly (or even more frequent) meter data with meter readings, therefore smart meters are being put in operation in a number of countries. Smart meters give a more accurate picture of electricity consumption, provide the parties with an accurate picture of grid status and can ease and shorten both the procedure of supplier switching and the process of dis- and re-connection due to unpaid bills. Indeed, the data reveals that the timeliest connection (activation) of LV network users takes place in one country where smart meters are already widely deployed and used for this purpose.

Recommendation #4

Maximise the benefits of high tech developments for customers

It is recommended to monitor the commercial quality performances, in order to ensure that the possible benefits of high tech developments - when implemented - provide value for money paid by the customers.

Finding #5
New trends in regulating customer relations

In addition to the customer's expectation to be connected or reconnected as quickly as possible (see Finding #3), there is the noticeable need for a substantive answer from the DSO/supplier to any customer query within a reasonable limit of time. The data reveals that emphasis is placed by the standards applied to the written form of communication. This results in an increasingly incomplete picture of the quality of responses to customer queries for two different reasons. The first is the fast growth in non-written forms of communication like telephone (fixed and cell-phone) and internet. The second is that in some countries the more traditional approach of visiting local customer centres continues.

Recommendation #5

Develop the regulation of customer relations

CEER recommends that NRAs consider the development of procedures on how to regulate both customer communications by phone and – if national practices require – visits to customer centres. Especially, in the increasingly important field of phone contacts, the performances of distribution operators and USPs should be monitored, with the aim of getting information for developing of regulations. Attention should be paid to a rapid, exhaustive and useful response.

Annex to Chapter 2 on Continuity of Supply: Data

TABLE A2.1.1 | Unplanned interruptions excluding exceptional events
Minutes lost per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				35.23	38.44	30.34	31.36	48.07	45.47	43.68	36.65	31.77
Bulgaria HV, MV										288.50	231.20	197.24
Czech Republic EHV, HV, MV, LV						102.54	120.50	102.50	124.23	86.70	102.65	106.24
Denmark HV, MV, LV									28.30	17.79	17.26	16.95
Estonia HV, MV, LV												
Finland EHV, HV, MV												
France EHV, HV, MV, LV	52.00	46.00	39.00	40.00	51.00	50.70	52.20	71.50	57.70	62.60	67.20	62.90
Germany EHV, HV, MV, LV								21.53	19.25	16.89	14.63	14.90
GB EHV, HV, MV, LV				81.66	81.28	76.59	68.64	65.55	78.03	74.22	73.43	70.02
Greece MV, LV										171.00	134.00	
Hungary HV, MV, LV	411.00	241.20	250.20	196.80	155.40	137.40	121.80	127.75	137.42	97.70	99.32	102.38
Ireland HV, MV, LV	227.60	187.00	183.00	183.00	162.00	156.50	154.90	123.90	115.40	94.10	81.30	82.00
Italy EHV, HV, MV, LV	164.52	159.22	138.57	108.88	96.83	76.52	65.74	53.84	52.47	53.10	49.45	47.77
Latvia HV, MV, LV												
Lithuania HV, MV, LV							92.39	89.28	92.21	78.43	52.54	58.92
The Netherlands EHV, HV, MV, LV	25.30	27.00	31.00	28.00	30.00	24.00	27.40	35.60	33.10	22.10	26.50	33.70
Norway EHV, HV, MV												
Poland EHV, HV, MV, LV											341.60	316.10
Portugal EHV, HV, MV, LV			421.86	334.54	303.75	148.81	142.82	152.08	104.33	133.08	185.62	172.98
Romania HV, MV, LV										638.00	635.00	
Slovak Republic EHV, HV, MV, LV											414.60	465.40
Slovenia EHV, HV, MV										59.00	54.00	51.00
Spain EHV, HV, MV, LV	156.37	145.41	179.69	142.56	141.91	123.60	117.00	112.80	103.92	86.82	88.74	
Sweden EHV, HV, MV, LV												78.90

TABLE A2.1.2 | Unplanned interruptions excluding exceptional events
Interruptions per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				0.59	0.67	0.61	0.67	0.87	0.77	0.75	0.79	0.66
Bulgaria HV, MV										5.63	5.12	4.65
Czech Republic EHV, HV, MV, LV						2.11	1.92	1.87	2.35	1.70	1.63	1.64
Denmark HV, MV, LV									0.62	0.58	0.47	0.49
Estonia HV, MV, LV												
Finland EHV, HV, MV												
France EHV, HV, MV, LV	1.20	1.20	1.20	1.15	1.40	1.30	1.02	1.30	0.98	1.16	1.00	0.92
Germany EHV, HV,MV, LV								0.46	0.33	0.32	0.29	0.26
GB EHV, HV, MV, LV				0.87	0.79	0.81	0.72	0.72	0.78	0.74	0.71	0.69
Greece MV, LV										2.30	2.10	
Hungary HV, MV, LV	3.09	2.29	2.13	2.03	2.05	1.90	1.77	1.77	1.88	1.54	1.49	1.45
Ireland HV, MV, LV	1.03	1.30	1.26	1.24	1.47	1.68	1.86	1.43	1.49	1.28	1.08	1.18
Italy EHV, HV, MV, LV		3.46	3.19	2.74	2.68	2.42	2.33	2.23	2.10	1.92	1.95	1.80
Latvia HV, MV, LV												
Lithuania HV, MV, LV							1.74	1.65	2.18	1.73	1.46	1.92
The Netherlands EHV, HV, MV, LV	0.41	0.41	0.38	0.34	0.34	0.32	0.30	0.45	0.33	0.31	0.33	0.38
Norway EHV, HV, MV												
Poland EHV, HV, MV, LV											4.00	3.70
Portugal EHV, HV, MV, LV			5.09	5.93	4.81	2.69	2.71	2.73	2.06	2.36	2.77	3.14
Romania HV, MV, LV										6.70	6.40	
Slovak Republic EHV, HV, MV, LV												
Slovenia EHV, HV, MV										1.80	1.49	1.39
Spain EHV, HV, MV, LV			3.30	2.65	2.60	2.52	2.31	2.38	2.23	1.99	2.01	
Sweden EHV, HV, MV, LV												1.32

TABLE A2.1.3 | Unplanned interruptions including all events
Minutes lost per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				83.08	38.44	30.34	39.41	48.07	72.33	85.68	38.18	31.77
Bulgaria HV, MV												
Czech Republic EHV, HV, MV, LV										185.54	210.94	135.88
Denmark HV, MV, LV									29.55	17.79	17.26	16.95
Estonia HV, MV, LV								243.49	185.83	405.33	186.69	195.97
Finland EHV, HV, MV	198.00	130.00	468.00	284.00	212.00	105.00	87.00	64.00	53.00	59.00	41.00	
France EHV, HV, MV, LV	55.00	46.00	59.00	42.00	69.30	57.10	55.90	86.30	61.60	74.10	173.80	95.10
Germany EHV, HV, MV, LV								23.25	35.67	16.96	15.29	19.27
GB EHV, HV, MV, LV				83.69	110.38	81.11	94.29	69.16	100.10	81.94	75.69	81.42
Greece MV, LV												
Hungary HV, MV, LV	411.00	241.20	250.20	196.80	155.40	137.40	121.80	127.75	141.00	111.00	125.00	132.59
Ireland HV, MV, LV	273.60	257.90	199.30	230.20	171.90	162.80	163.60	148.30	129.70	108.90	100.40	110.00
Italy EHV, HV, MV, LV	191.77	187.40	149.09	114.74	546.08	90.53	79.86	60.55	57.89	89.64	78.67	88.84
Latvia HV, MV, LV												
Lithuania HV, MV, LV							373.57	168.70	301.70	155.65	122.12	260.03
The Netherlands EHV, HV, MV, LV	25.30	27.00	31.00	28.00	30.00	24.00	27.40	35.60	33.10	22.10	26.50	33.70
Norway EHV, HV, MV							93.00	113.00	96.00	104.00	84.00	66.00
Poland EHV, HV, MV, LV									410.00	352.50	408.60	385.50
Portugal EHV, HV, MV, LV			530.74	467.98	406.18	217.79	198.73	243.19	136.00	162.67	280.03	276.04
Romania HV, MV, LV										696.00	682.00	
Slovak Republic EHV, HV, MV, LV												
Slovenia EHV, HV, MV										116.00	133.00	81.00
Spain EHV, HV, MV, LV	156.37	145.41	179.69	142.56	141.91	123.60	117.00	112.80	103.80	86.82	133.86	
Sweden EHV, HV, MV, LV	165.80	89.20	162.90	101.80	148.10	78.10	912.60	100.00	321.90	110.80	73.30	91.90

TABLE A2.1.4 | Unplanned interruptions including all events
Interruptions per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				0.77	0.67	0.61	0.69	0.87	0.90	0.99	0.80	0.66
Bulgaria HV, MV												
Czech Republic EHV, HV, MV, LV										2.22	2.00	1.78
Denmark HV, MV, LV									0.64	0.56	0.47	0.49
Estonia HV, MV, LV								1.54	2.05	4.56	1.84	2.07
Finland EHV, HV, MV	3.30	2.90	6.60	3.30	4.00	4.30	1.90	1.80	1.60	1.60	1.20	
France EHV, HV, MV, LV	1.22	1.20	1.20	1.20	1.43	1.30	1.08	1.33	0.98	1.18	1.10	0.98
Germany EHV, HV, MV, LV								0.46	0.43	0.33	0.30	0.30
GB EHV, HV, MV, LV				0.87	0.86	0.83	0.78	0.74	0.88	0.77	0.73	0.72
Greece MV, LV												
Hungary HV, MV, LV	3.09	2.29	2.13	2.03	2.05	1.90	1.77	1.79	1.92	1.62	1.69	1.63
Ireland HV, MV, LV	1.15	1.49	1.31	1.37	1.50	1.70	1.95	1.60	1.57	1.39	1.2	1.32
Italy EHV, HV, MV, LV		3.59	3.29	2.76	3.96	2.48	2.42	2.29	2.16	2.38	2.36	2.27
Latvia HV, MV, LV												
Lithuania HV, MV, LV							1.02	1.05	1.19	1.10	0.81	0.82
The Netherlands EHV, HV, MV, LV	0.41	0.41	0.38	0.34	0.34	0.32	0.30	0.45	0.33	0.31	0.33	0.38
Norway EHV, HV, MV							1.54	1.75	1.70	1.79	1.70	1.50
Poland EHV, HV, MV, LV									3.10	4.10	4.10	3.80
Portugal EHV, HV, MV, LV			7.51	7.35	5.96	3.66	3.54	3.81	2.62	2.80	3.63	4.32
Romania HV, MV, LV										6.90	6.50	
Slovak Republic EHV, HV, MV, LV												
Slovenia EHV, HV, MV										2.71	2.40	1.81
Spain EHV, HV, MV, LV			3.30	2.65	2.60	2.52	2.31	2.38	2.23	1.99	2.19	
Sweden EHV, HV, MV, LV	1.38	1.22	1.35	1.32	1.64	1.10	1.49	1.28	1.70	1.38	1.32	1.33

TABLE A2.1.5 | Planned interruptions
Minutes lost per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				7.40	12.79	20.70	20.97	22.38	18.77	19.57	17.17	19.87
Bulgaria HV, MV										299.50	289.70	224.21
Czech Republic EHV, HV, MV, LV						148.29	166.19	144.70	150.23	165.82	140.65	159.40
Denmark HV, MV, LV									8.89	8.45	8.11	5.10
Estonia HV, MV, LV								118.59	202.20	195.26	145.04	236.70
Finland EHV, HV, MV	103.00	38.00	33.00	32.00	32.00		23.00	26.00	23.00	23.00	18.00	
France EHV, HV, MV, LV	4.00	6.00	6.00	6.00	5.30	6.60	8.00	7.90	10.80	19.40	23.20	24.00
Germany EHV, HV, MV, LV								15.10	13.85	13.17	11.53	9.65
GB EHV, HV, MV, LV									4.96	5.70	6.48	6.72
Greece MV, LV											219.00	
Hungary HV, MV, LV		100.06	139.58	137.02	199.24	178.95	138.50	139.86	144.66	156.99	198.17	179.65
Ireland HV, MV, LV	172.00	164.70	202.00	284.10	422.30	390.70	375.40	268.70	79.00	60.50	59.3	64.1
Italy EHV, HV, MV, LV		82.62	84.82	77.97	80.67	62.62	58.77	53.79	46.16	49.35	43.58	55.71
Latvia HV, MV, LV												
Lithuania HV, MV, LV							113.62	98.27	71.23	78.07	93.29	132.72
The Netherlands EHV, HV, MV, LV								2.81	3.39	4.13	4.04	4.35
Norway EHV, HV, MV							44.00	42.00	48.00	44.00	42.00	36.00
Poland EHV, HV, MV, LV									121.00	152.20	145.80	129.80
Portugal EHV, HV, MV, LV			57.37	52.21	62.39	49.16	39.16	18.70	7.31	2.07	2.00	1.57
Romania HV, MV, LV										385.00	323.00	
Slovak Republic EHV, HV, MV, LV												
Slovenia EHV, HV, MV										138.00	130.00	104.00
Spain EHV, HV, MV. LV	31.36	37.05	36.57	30.66	24.79	21.60	13.80	9.60	11.40	10.80	8.34	
Sweden EHV, HV, MV, LV	90.07	34.50	42.30	37.10	25.40	24.80	33.50	23.80	23.20	26.40	21.30	20.10

TABLE A2.1.6 | Planned interruptions
Interruptions per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Austria HV, MV				0.07	0.13	0.17	0.18	0.19	0.19	0.18	0.16	0.17
Bulgaria HV, MV										5.25	5.29	3.61
Czech Republic EHV, HV, MV, LV						0.57	0.57	0.55	0.56	0.62	0.54	0.59
Denmark HV, MV, LV									0.06	0.06	0.06	0.04
Estonia HV, MV, LV								0.52	0.50	1.31	0.58	0.51
Finland EHV, HV, MV	1.80	1.30	0.60	0.50	0.50		0.30	0.40	0.40	0.3	0.3	
France EHV, HV, MV, LV	0.03	0.04	0.04	0.04	0.04	0.05	0.06	0.06	0.11	0.21	0.24	0.21
Germany EHV, HV, MV, LV									0.13	0.10	0.10	0.09
GB EHV, HV, MV, LV									2.04	2.27	2.54	2.62
Greece MV, LV											1.1	
Hungary HV, MV, LV		0.35	0.55	0.54	0.75	0.71	0.54	0.57	0.55	0.59	0.66	0.61
Ireland HV, MV, LV	0.51	0.43	0.49	0.66	0.76	0.67	0.89	0.68	0.28	0.24	0.24	0.25
Italy EHV, HV, MV, LV		0.61	0.59	0.49	0.49	0.40	0.37	0.34	0.30	0.35	0.29	0.38
Latvia HV, MV, LV												
Lithuania HV, MV, LV							0.4	0.36	0.25	0.26	0.33	0.47
The Netherlands EHV, HV, MV, LV								0.02	0.02	0.03	0.02	0.03
Norway EHV, HV, MV							0.32	0.30	0.30	0.32	0.3	0.30
Poland EHV, HV, MV, LV									0.40	0.7	0.8	0.7
Portugal EHV, HV, MV, LV			0.32	0.29	0.30	0.23	0.19	0.09	0.04	0.02	0.01	0.01
Romania HV, MV, LV										1.6	1.5	
Slovak Republic EHV, HV, MV, LV												
Slovenia EHV, HV, MV										1.09	1.05	0.85
Spain EHV, HV, MV. LV			0.42	0.26	0.2	0.19	0.09	0.08	0.09	0.08	0.06	
Sweden EHV, HV, MV, LV	0.45	0.25	0.23	0.26	0.22	0.18	0.22	0.2	0.32	0.51	0.23	0.18

TABLE A2.1.7 | Unplanned interruptions excluding exceptional events - different areas
Minutes lost per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
France urban						27.1	36.9	40.6	28.6	39.2	45.6	34
France suburban						40.8	43.4	54.3	42.1	50.8	52.1	46.6
France rural						94.2	73.3	116.9	100.4	96.9	102.2	105
Italy urban	86.71	84.33	71.23	54.66	53.01	41.31	43.7	40	42.26	40.27	38.59	37.93
Italy suburban	149.09	170.19	152.58	112.32	90.67	72.21	63.71	54.4	52.52	50.33	48.71	47.9
Italy rural	282.47	229.18	193.7	170.97	165.11	129.82	98.57	69.7	64.84	74.54	64.22	59.42
Romania urban										314	319	
Romania suburban												
Romania rural										1038	1026	
Portugal urban			154.98	130.86	145.23	82.73	92.99	98.08	51.9	60.45	112.35	76.65
Portugal suburban			256.19	260.23	231.29	120.52	115.68	112.17	73.35	95.1	168.45	115.64
Portugal rural			637.53	475.48	429.72	201.64	183.32	206.39	152.38	195.66	348.05	260.54
Slovenia urban										13	14	14
Slovenia suburban										5	5	6
Slovenia rural										41	35	31

TABLE A2.1.8 | Unplanned interruptions excluding exceptional events - different areas
Interruptions per year (1999-2010)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
France urban						0.73	0.80	0.96	0.65	0.91	0.81	0.65
France suburban						0.93	0.98	1.18	0.90	1.02	0.94	0.86
France rural						1.45	1.28	1.77	1.38	1.53	1.28	1.28
Italy urban		1.92	1.91	1.59	1.65	1.424	1.546	1.552	1.56	1.337	1.321	1.234
Italy suburban		3.46	3.13	2.71	2.55	2.407	2.33	2.195	2.07	1.884	1.955	1.806
Italy rural		5.27	4.81	4.21	4.19	3.793	3.302	3.055	2.72	2.612	2.595	2.44
Romania urban										4.20	4.20	
Romania suburban												
Romania rural										9.80	9.10	
Portugal urban			2.53	2.53	2.33	1.66	1.79	1.48	1.24	1.49	2.73	1.75
Portugal suburban			4.41	4.67	3.98	2.32	2.43	2.28	1.62	1.86	3.48	2.30
Portugal rural			8.43	8.19	6.86	3.63	3.39	3.81	2.93	3.45	6.38	4.61
Slovenia urban										0.43	0.41	0.42
Slovenia suburban										0.16	0.12	0.12
Slovenia rural										1.21	0.96	0.85

TABLE A2.1.9 | Definitions and methods for exceptional events

Country	Is there a regulatory definition of "Exceptional events"?	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
AUSTRIA	Natural disaster: announcement of crisis from local authorities or documented measures from regional or national government related to e.g. catastrophe funds.	Included	No method applied but currently under discussion.
BULGARIA	Force majeure - an extraordinary event which: (1) can not be foreseen, prevented or controlled and (2) leads to disturbances in the normal functioning of the electricity distribution network and (3) has been verified by the competent authorities - ensuing from human activities: military activities, terrorism, embargo, prohibitions imposed by the government, strikes, riots, uprisings. - of natural character: storms (with speed above 60 km/h), torrential rains, floods, hailstorms, thunderbolts, snow avalanches, landslides.	Excluded	No, there is no such method available.
CZECH REPUBLIC	No, individual approach.	Statistics with and without.	No
DENMARK	Force majeure due to storm surge, flood, hurricane or other incidents that NRA approves as force majeure.	Excluded	No
ESTONIA	Interruption causes a long time event that network operator could not foresee (example natural disaster, lightning that exceeds design norms, heavy winds, glazed frost, sabotage actions).	Statistics with and without.	Yes, criteria by extent of interruptions.
FINLAND	No. There isn't any regulatory definition of "Exceptional events".	Included	No
FRANCE	Yes	Statistics with and without.	Yes,for climatic events, exceptional events definition is based on both: 1. breadth (simultaneous outage for more than 100,000 final customers) 2. local occurrence of this type of climatic event (less than 1/20 years), according to meteorological data.
GERMANY	Yes, there is a definition of "Exceptional events" (in Germany it is called "force majeure").	Excluded	No
GREECE	No, there is no regulatory definition.	Statistics with and without.	Yes, exceptional weather conditions day: the number of interruptions for a distribution area is at least three times the yearly average number of interruptions for this distribution area.

Country	Is there a regulatory definition of "Exceptional events"?	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
HUNGARY	No, there is no definition of exceptional events, but: 1. In Guaranteed Standards: there is a definition of "extreme weather": if the number of MV interruptions caused by a weather event reaches or exceeds a value predefined for the different DSOs. 2. Overall Standards: there is a definition of "other event", which includes the following: a) system collapse b) terror attacks c) every event, which is designated as an "other event" by the NRA.	Statistics with and without.	Yes. 1. In the Guaranteed Standards there is a method to define "exceptional condition periods", which is similar to UK practice. If the number of MV interruptions in any 24 hour interval is eight (I. category) or thirteen times (II. category) above that of the (8 year) average, then it is considered an "extreme weather condition period". 2. Overall Standards: strain exceeding the design requirements e.g. wind speed over 100km/h.
IRELAND	There is a definition of 'storm days', but no other exceptional events are defined.	Statistics with and without.	Yes. Storm days are days where the reported customer hours lost due to faults is greater than 61.570. 61.570 was the average of two standard deviations from the mean of the daily fault data for the 3 years 1999, 2000, and 2001.
ITALY	Force majeure is used.	Statistics with and without.	Yes. In addition to document-proven force majeure (for T and for D), a statistical method is used for the distribution network. It refers to the past number of interruptions in 6 hour period.
LITHUANIA	No	Included	No
THE NETHERLANDS	Examples of "extreme situations" are earthquakes, floods, extraordinary weather conditions, terrorist attacks and war.	Included	No
NORWAY	Yes, please see 4th BR, Table 2.13 page 49.	Included	No
POLAND	According to the definition of "force majeure" given in the Transmission Grid Code approved by the regulator. Exceptional includes sudden events, unpredictable and independent from will of the parties, which makes it impossible to meet contracts.	Statistics with and without.	No
PORTUGAL	No. In Portugal there is not a definition for "Exceptional events", definition related to the unlikely occurrence.		
ROMANIA	General definition but the exceptional events/force majeure has to be confirmed by the Chamber of Commerce, Industry and Agriculture.	Included	No. The Chamber decides.
SLOVAK REPUBLIC	Emergency, natural disaster, damage on TSO and DSO installations caused by third party.	Excluded	No

Country	Is there a regulatory definition of "Exceptional events"?	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
SLOVENIA	Force majeure is: a) a natural unforeseeable event which is beyond the control of the system operator (precipitations (snow, sleet), hurricane, avalanche (snowslide, landslide), fire, flood, earthquake or similar natural disaster which leads to declaration of crisis situation by the authorities), and whose effects on continuity of supply cannot be predicted and prevented or avoided. b) non-natural event (i.e. war), which leads to declaration of crisis situation by the authorities. An interruption of supply can be qualified as "force majeure" only in cases were it was caused by the event beyond the control of system operator and in cases when the system operator could not prevent or avoid the event (the cause was unpredictable, irresistible and external to the network). The system operator must have written evidence that network design criteria have been exceeded for each interruption that is classified as "force majeure" due to more severe conditions than the ones considered in the network design requirements.	Statistics with and without.	No
SPAIN	Yes. Special event is authorised by the Directorate General for Energy and Mines, and has natural causes and generally occurs in at least 10% of the municipalities on the peninsula or at least 50% of municipalities each island and peninsular system.	Included	Yes
SWEDEN	There is a definition in the electricity act, but it does not apply for registration of interruptions. Instead, a separation between interruption up to and including 12 hours and longer than 12 hours is done. Only interruptions up to 12 hours are considered for the economic regulation.		No
GREAT BRITAIN	Yes. Ofgem has a regulatory definition of exceptional events and excludes the impact of these from the network operators' performance.	Excluded	Yes. Severe weather events are defined as any event that results in more than eight times the average number of higher voltage (1kV and above) faults in a licence area over a 24 hour period. These events further fall into three categories.

Case Study 2

Statistical correlation between the percentage of underground MV cables and continuity of supply - Analysis of local data regarding the situation in France

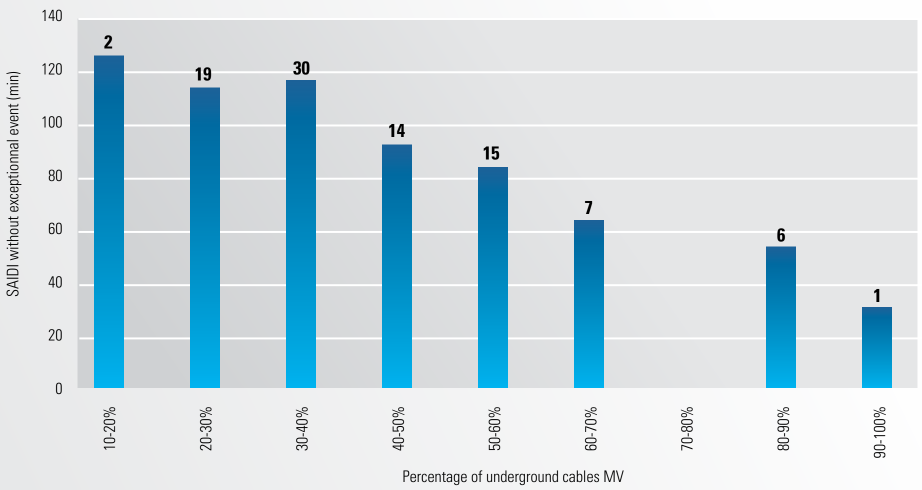
It is well-established that undergrounding barely impacts the continuity of supply in France provided exceptional events are not taken into account. Yet, French data analysis leads to positive statistical correlations between the percentage of underground MV cables and continuity of supply. The following explanations behind this correlation illustrate the need to be cautious before drawing conclusions from statistical correlations.

Figure A2.1 presents an analysis based on data from 94 "départements" (French administrative entities), corresponding to 95% of the distribution networks in mainland France. It shows unplanned SAIDI (without exceptional events) plus planned SAIDI, averaged over 3 years (2008-2010) - for each group of "département", arranged according to the percentage of underground cables in their MV network (2010).

Yet, such a statistical correlation cannot simply be explained by the positive impact of undergrounding on continuity of supply. High percentages of underground MV cables correspond to high density areas which relate, due to historical reasons, primarily to urbanisation. In such areas, the high density of end-users naturally allows a high level of redundancy in MV distribution networks, which to a very large extent explains the high continuity of supply - much more than the high percentage of underground MV cables per se, even though their respective impacts are not precisely quantifiable. In rural areas, which are more exposed to climatic events, the percentage of underground MV cables may have an important impact on the continuity of supply, but only when large storms occur. This impact is not significant in indicators that do no take exceptional events into account. In addition, for "départements" not concerned by the risk of climatic events, the impact of undergrounding MV networks can be negligible.

Thus, in the French case, the positive correlation between the percentage of underground MV cables and continuity of supply can be understood in two ways: (1) continuity of supply is determined to a very large extent by the level of redundancy in networks; and (2) a high percentage of underground MV cables and a high level of redundancy are direct consequences of a high density.

FIGURE A2.1 | Statistical correlation between the percentage of underground cables in MV networks "SAIDI" (unplanned SAIDI without exceptional events plus planned SAIDI) in France



NB: The numbers above the bars indicate the number of "départments" in the group

Case Study 3

Continuity of supply in Sweden

In Sweden, electricity distribution is managed by 172 different DSOs, each of which reports a range of statistics to the NRA on an annual basis. This data has been used to obtain the figures below.

The vertical axis in Figure A.2.2 gives the total SAIDI (planned and non-planned interruptions) for 153 DSOs. The value presented here is the average over the period 2004 through 2008. All interruptions due to incidents within the network owned by the DSO are included, including exceptional events. Interruptions due to incidents in other networks, however, are not included here.

The horizontal axis gives the percentage of underground cables in the DSOs networks; again as an average over the period 2004 through 2008. Four DSOs reported an average total SAIDI above 500 min/year; these are not shown in the figure. Some other DSOs have been removed from the statistics here because the service territory has changed during these five years.

With increasing percentage of underground cables, there is a clearly decreasing trend in unavailability. Also, the spread between different DSOs is lower as the percentage of underground cables increases.

Figure A.2.3 shows the relationship between availability and customer density. The customer density (horizontal axis) is quantified as the number of meters of cable and line per user within the service territory of the DSO. In this case, the 2008 value has been used; the value does not show any significant changes between the years.

The figure shows an overall increase in total SAIDI with increasing average distance between customers.

The relatively high percentage of underground cables in Sweden can partly be explained because of the replacement of overhead lines by underground cables especially since 2005 when a major storm resulted in extremely long interruptions in overhead networks. An additional driver is the legislation on compensation for interruptions longer than 12 hours and the requirement that no interruption shall be longer than 24 hours.

The replacement of overhead lines by underground cables is illustrated in Figure A.2.4 for voltage levels 1000 Volt or lower (labelled "LV" in the figure) and for voltage levels above 1000 Volt in the local distribution networks (labelled "MV/HV"). The growth in total feeder length (cables plus lines) was about 7% during this period.

FIGURE A2.2 | Relation between the total SAIDI and the percentage of underground cables for DSOs in Sweden

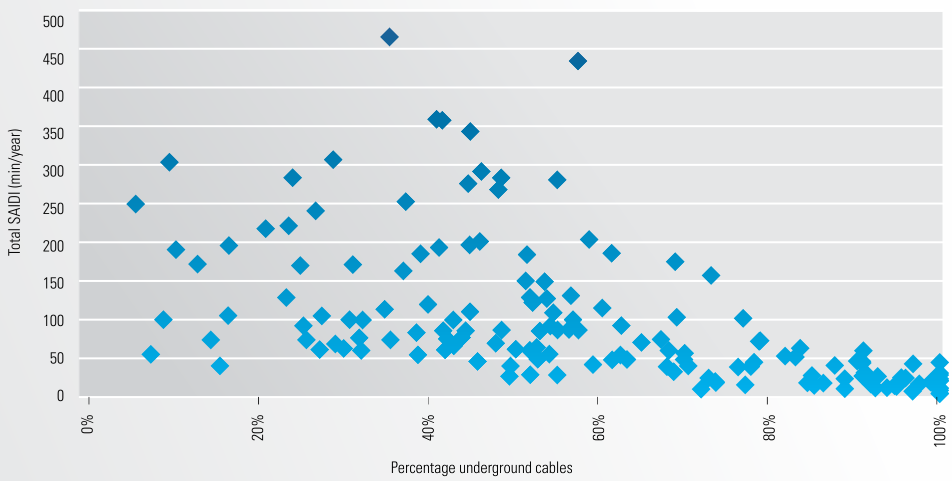


FIGURE A2.3 | Relationship between total SAIDI and customer density for DSOs in Sweden

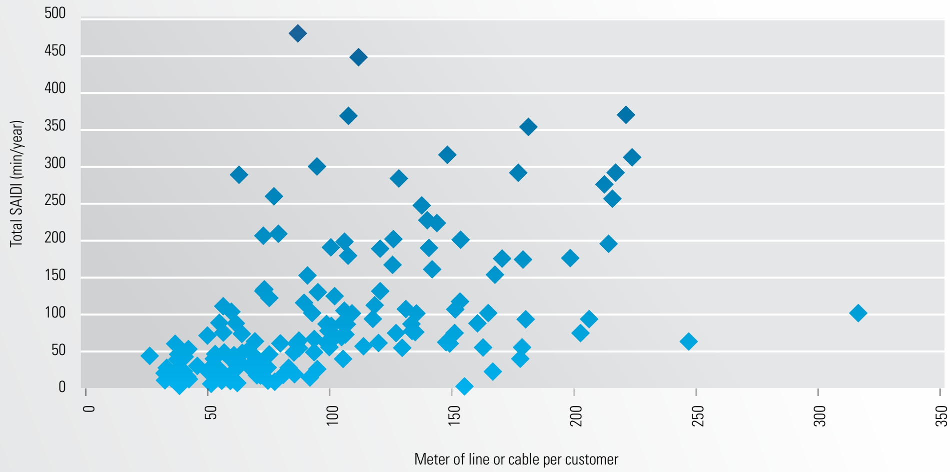
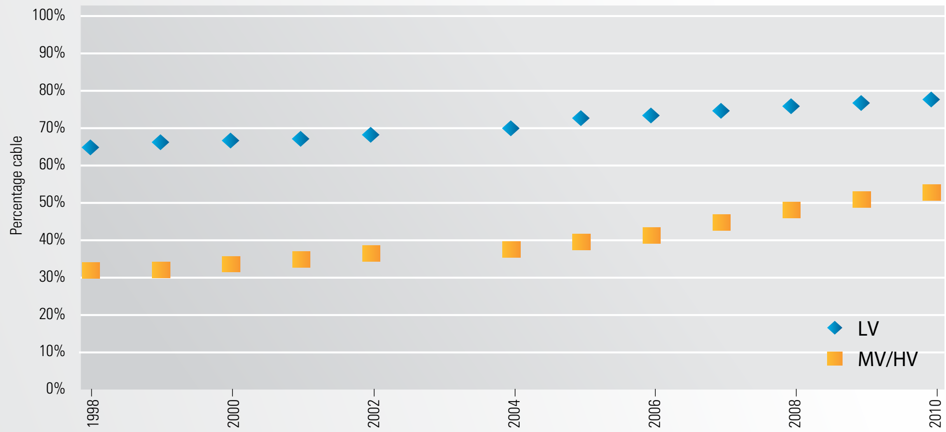


FIGURE A2.4 | Growth in underground networks in Sweden, 1998-2010



Annex to Chapter 3 on Voltage Quality: Data

Part 1:
National legislation and regulations that differ from EN 50160

Cyprus

- Power frequency - local areas (HV, MV, LV): As per CYS EN 50160:
  - 49.5-50.5 Hz Normal Operation
  - 47.0-52.0 Hz Emergency Operation
- Power frequency – interconnected areas (LV): not applicable
- Supply voltage variations (MV, LV)
- Flicker (HV, MV, LV): As per CYS EN 50160 and IEC 61000-3-7 ($P_{st} \leq 0,35$ & $P_{lt} \leq 0,35$)
- Voltage dips (MV, LV): As per CYS EN 50160
- Voltage swells (MV, LV): As per CYS EN 50160
- Harmonic voltage (HV, MV, LV): As per CYS EN 50160 and IEC 61000-3-7 (≤2%) by TSO
- Single rapid voltage change (HV): IEC 61000-3-7 (≤3%) by TSO

The Czech Republic

- Flicker (HV, MV, LV): Pst< 0.8, Plt < 0.6
- Harmonic voltage: (HV): Max. amplitude of harmonic uh [% Un] - Max. THD [%]:
  - 110 kV - 2.0 - < 2.5
  - 220 kV - 1.5 - < 2.0
  - 400 kV - 1.0 - < 1.5
- Single rapid voltage change (HV): Number of changes [r/h] - dumax [% Un]:
  - r < 1 - 3
  - 1 < r <10 - 2.5
  - 10 < r <100 - 1.5
  - 100 < r <1,000 – 1

France

- Power frequency – local areas (HV, MV)
- Power frequency – interconnected areas (HV, MV)
- Supply voltage variations (HV, MV)
- Flicker (HV, MV)
- Voltage unbalance (HV, MV)

Hungary

- Supply voltage variations (LV):
- 10 minute mean values of supply voltage variations shall be within Un ±7.5% for 95% of the week and within Un ±10% for 100% of the week
- Each 1 minute mean value of supply voltage variations shall be within Un +15% / -20% for 100% of the week

Italy

- Power frequency - local areas (HV):
  - HV:
    - 49.5 - 50.5 Hz under normal (i.e. with respect to "N-1 security" criterion) or alarm (i.e. with respect to "N security" criterion but not "N-1 security") operational states (Sicily and Sardinia islands)
    - 47.5 - 51.5 Hz under emergency (i.e. interruption) or restoration operational state
- Power frequency – interconnected areas (HV, MV):
  - HV:
    - 49.9 - 50.1 Hz under normal or alarm operational state (Italian mainland peninsula)
    - 47.5 - 51.5 Hz under emergency or restoration operational state
  - MV, temporary islanding operation of normally interconnected MV networks:
    - 49 - 51 Hz for 95% of time
    - 47.5 - 51.5 Hz for 100% of time
- Supply voltage variations (EHV, HV, MV):
  - For EHV:
    - 380 kV operated at 400 kV - 95% of time in the range 375 - 415 kV under normal operational state; 100% of time in the range 360 - 420 kV under normal or alarm operational state; 100% of time in the range 350 - 430 kV under emergency or restoration operational state; 220 kV operated at 230 kV - 95% of time in the range 222 - 238 kV under normal operational state; 100% of time in the range 200 - 242 kV under normal or alarm operational state; 100% of time in the range 187 - 245 kV under emergency or restoration operational state
- For HV:
  - 150 kV operated at 150 kV - 95% of time in the range 143 - 158 kV under normal operational state; 100% of time in the range 140 - 165 kV under normal or alarm operational state; 100% of time in the range 128 - 170 kV under emergency or restoration operational state; 132 kV operated at 132 kV - 95% of time in the range 125 - 139 kV under normal operational state; 100% of time in the range 120 - 145 kV under normal or alarm operational state; 100% of time in the range 112 - 150 kV under emergency or restoration operational state
  - Temporary islanding operation of normally interconnected MV networks:
    - Upper limit 110% Un
    - Lower limit 85% Un
- Flicker (HV): Indicators Pst and Plt are defined (limits only for Pst):
  - EHV (380 kV): Pst 1 p.u.
  - EHV (220 kV): Pst 4 p.u.
  - HV (150-132 kV): Pst 6 p.u.

The 'planning levels' of Pst and Plt are:

  - EHV: Pst <0.70 p.u. and Plt < 0.50 p.u.
  - HV: Pst <0.85 p.u. and Plt < 0.62 p.u.
- Voltage dips (HV):
  - EHV (380 kV): 50 POLI-ALL and 200 MONO-ALL; 3 POLI-SEVERE and 5 MONO-SEVERE
  - EHV (220 kV): 100 POLI-ALL and 200 MONO-ALL; 6 POLI-SEVERE and 10 MONO-SEVERE
  - HV (150-132 kV): 250 POLI-ALL and 400 MONO-ALL; 9 POLI-SEVERE and 15 MONO-SEVERE

4 indicators:

  - POLI-ALL poli-phase voltage dips (U<90%)
  - MONO-ALL mono-phase voltage dips (U<90%)
  - POLI-SEVERE poli-phase voltage dips (U<70% and t>0,5s)
  - MONO-SEVERE mono-phase voltage dips (U<70% and t>0,5s)
- Voltage unbalance (HV): The network code specifies that the unbalance for HV networks is generally lower than 1% in normal conditions. Reference levels for EHV and HV: 2%. The indicator is the 95%-weekly value (as of EN 50160).
- Harmonic voltage (HV): The network code specifies that the THD for HV networks is lower than 3% in normal conditions. Reference levels for EHV and HV: 6%. The indicator is THD calculated for harmonics 2-25 (note this is different than EN 50160).

Latvia

- Power frequency – interconnected areas (MV, LV): Same as EN 50160:2007
- Supply voltage variations (LV): Un +/- 10% for 95% of the values averaged over 10 minutes during 1 week. In some cases +10% -15%
- Flicker (LV): Same as EN 50160:2007
- Voltage dips (LV): Same as EN 50160:2007
- Voltage swells (LV): Same as EN 50160:2007
- Voltage unbalance (LV): Same as EN 50160:2007
- Harmonic voltage (LV): Same as EN 50160:2007

The Netherlands

- Power frequency – interconnected areas (HV, MV, LV): 50 Hz +/- 1% during 99.9% of any year, 50 Hz + 4% / -6% of any year
- Supply voltage variations (HV, MV, LV):
  - For networks Un < 35 kV:
    - Un +/- 10% for 95% of the values averaged over 10 minutes during 1 week
    - Un +10 / -15% for all values averaged over 10 minutes during 1 week
  - For networks >= 35 kV:
    - Uc +/- 10% for 99.9% of the values averaged over 10 minutes during an examination period of 1 week
- Flicker (HV, MV, LV):
  - Plt <= 1 during 95% of the values averaged over 10 minutes during an examination period of 1 week
  - Plt <= 5 for all values averaged over 10 minutes during an examination period of 1 week
- Voltage dips (HV): No limits set at the moment
- Voltage swells (HV)
- Voltage unbalance (HV, MV, LV):
  - For networks with Uc < 35 kV: same requirements as in EN 50160, but in addition, the inverse component of the voltage shall be between 0 and 3% of the normal component for all measurement periods
  - For networks Uc >= 35 kV: inverse component <= 1% of the normal component during 99.9% of the values averaged over 10 minutes during an examination period of 1 week
- Harmonic voltage (HV, MV, LV):
  - For networks of Uc < 35 kV:
    - The relative voltage per harmonic voltage shall be smaller than the percentage of 95% of the values averaged over 10 minutes stated in the standard. The smallest value given in the standard shall apply to harmonics that are not stated
    - THD <= 8% for all harmonic voltages up to and including the 40^{th}, during 95% of the time
    - The relative voltage per harmonic voltage shall be smaller than 3/2 x the percentage of 99.9% of the values averaged over 10 minutes stated in the standard
    - THD <= 12% for all harmonic voltages up to and including the 40^{th}, during 99.9% of the time
  - For networks of Uc >= 35 kV and Uc < 150 kV:
    - THD <= 6% for all harmonic voltages up to and including the 40^{th}, during 95% of the values averaged over 10 minutes during an examination period of 1 week
    - THD <= 7% for all harmonic voltages up to and including the 40^{th}, during 99.9% of the values averaged over 10 minutes during an examination period of 1 week
  - For networks of Uc >= 220 kV:
    - THD <= 5% for all harmonic voltages up to and including the 40^{th}, during 95% of the values averaged over 10 minutes during an examination period of 1 week
    - THD <= 6% for all harmonic voltages up to and including the 40^{th}, during 99.9% of the values averaged over 10 minutes during an examination period of 1 week

Norway

- Power frequency - local areas (HV, MV, LV): In systems temporarily without physical connections to adjacent transmission grids, the TSO (Statnett) shall ensure that the voltage frequency is normally kept within 50 Hz ± 2%.
- Power frequency – interconnected areas (HV, MV, LV): The TSO (Statnett) shall ensure that the voltage frequency and time deviations are normally kept within the provisions of the Nordic system operation agreement.
- Supply voltage variations (LV): The DSOs shall ensure that supply voltage variations are within the range of ± 10% of the nominal value measured as 1-minute mean values, in connection points in the low-voltage system.
- Flicker (HV, MV, LV):
  - Limits for Pst (short term flicker severity) 95% of the week:
    - 0.23 ≤ UN ≤ 35 [kV]: 1.2 [pu]
    - 35 < UN [kV]: 1.0 [pu]
  - Limits for Plt (long term flicker severity) 100 % of the time:
    - 0.23 ≤ UN ≤ 35 [kV]: 1.0 [pu]
    - 35 < UN [kV]: 0.8 [pu]

- Voltage dips (HV, MV, LV): See limits given for rapid voltage change
- Voltage swells (HV, MV, LV): See limits given for rapid voltage change
- Voltage unbalance (HV, MV, LV): The TSO/DSOs shall ensure that the degree of voltage unbalance does not exceed 2% in connection points, measured as ten-minute mean values.
- Harmonic voltage (HV, MV, LV):
  - 0.23 ≤ UN ≤ 35 [kV]:
    - THD 100% of the time ≤ 8% (10-min mean values) and ≤ 5% (1 week mean value)
    - INDIVIDUAL HARMONIC VOLTAGE: Same as Table 1 in EN 50160, but for 100% of the time. Plus general limits above 25^{th} harmonic order (all 10 min mean values)
  - 35 ≤ UN ≤ 245 [kV]:
    - THD ≤ 3% (10-min mean values) 100% of the time
    - INDIVIDUAL HARMONIC VOLTAGE: Limits for all harmonic orders (10-min mean values, 100% of the time)
  - 245 < UN [kV]:
    - THD ≤ 2% (10-min mean values) 100% of the time
    - INDIVIDUAL HARMONIC VOLTAGE: Limits for all harmonic orders (10-min mean values, 100% of the time)
- Single rapid voltage change (HV, MV, LV): The TSO/DSOs shall ensure that rapid voltage changes do not exceed the following limits in connection points with respect to the nominal voltage, UN, maximum number per 24-hour period:
  - deltaU,steady state ≥ 3%:
    - max [#]: 24 for 0.23 ≤ UN ≤ 35 [kV]
    - max [#]: 12 for 35 < UN [kV]
  - deltaU,max: ≥ 5%:
    - max [#]: 24 for 0.23 ≤ UN ≤ 35 [kV]
    - max [#]:12 for 35 < UN [kV]

Portugal

- Supply voltage variations (HV): For VHV and HV the Quality of Service Code establishes that the value of Uc shall be within the range of Un±7% Un. Under normal operating conditions, during each period of 1 week, 95% of the 10 min mean r.m.s. values of the supply voltage shall be within the range of Uc±5% Uc.
- Flicker (HV): For VHV and HV the Quality of Service Code establishes that under normal operating conditions, in any period of 1 week the long and the short term flicker severity caused by voltage fluctuation should be lower than 1.
- Voltage dips (HV): Limits are not established
- Voltage unbalance (HV)
- Harmonic voltage (HV): For VHV and HV, under normal conditions, during each period of 1 week, 95% of the 10 min mean r.m.s. values of each individual harmonic voltage, Uh (%), shall be less or equal than:
  - h=5: 4.5 (HV); 3.0 (VHV)
  - h=3: 3.0 (HV); 2.0 (VHV)
  - h=2: 1.6 (HV); 1.5 (VHV)
  - h=7: 3.0 (HV); 2.0 (VHV)
  - h=9: 1.1 (HV); 1.0 (VHV)
  - h=4: 1.0 (HV); 1.0 (VHV)
  - h=11: 2.5 (HV); 1.5 (VHV)
  - h=15: 0.3 (HV); 0.3 (VHV)
  - h=6: 0.5 (HV); 0.5 (VHV)
  - h=13: 2.0 (HV); 1.5 (VHV)
  - h=21: 0.2 (HV); 0.2 (VHV)
  - h=8: 0.4 (HV); 0.4 (VHV)
  - h=17: 1.3 (HV); 1.0 (VHV)
  - h=>21: 0.2 (HV); 0.2 (VHV)
  - h=10: 0.4 (HV); 0.4 (VHV)
  - h=19: 1.1 (HV); 1.0 (VHV)
  - h=12: 0.2 (HV); 0.2 (VHV)
  - h=23: 1.0 (HV); 0.7 (VHV)
  - h=>12: 0.2 (HV); 0.2 (VHV)
  - h=25: 1.0 (HV); 0.7 (VHV)
  - h>25: 0.2+12.5/h (HV and VHV)THDHV=<8%; THDVHV=<4%

Sweden

- Supply voltage variations (HV, MV, LV): U +/- 10%; 100% of time over a week.
- Voltage dips (HV, MV, LV): The dip-table is divided in the three areas A, B and C. Dips with a duration and severity that puts them in area A is regarded a normal part of the operation of the network. Dips within area B need to be investigated and dips in area C are not allowed. The borders between the areas are slightly different for voltages above and below 45 kV.
- Voltage swells (LV): The swell-table is divided in the three areas A, B and C. Swells with a duration and severity that puts them in area A is regarded a normal part of the operation of the network. Swells within area B need to be investigated and swells in area C are not allowed.
- Voltage unbalance (HV, MV, LV): Unbalance must be equal to, or under, 2%; 100% of the time over a week.
- Harmonic voltage (HV, MV, LV): Same as EN 50160; 100% of the time over a week.
- Single rapid voltage change (HV, MV, LV): A maximum number of voltage changes are allowed.

Part 2: Voltage quality data

This annex provides an overview of the voltage quality data that countries have provided in response to the internal questionnaire for the 5th Benchmarking Report. The responding countries for this annex include France, Hungary, Italy, the Netherlands, Portugal and Slovenia. Most of the voltage quality data concerns voltage dips.

FRANCE

Below are 6 tables with voltage dip data from France for the period from 2008 up to and including 2010. Both the average number of dips and the 95th percentile have been included.

TABLE A3.1 | The average number of voltage dips per year in the transmission networks in France in 2008

Residual	Duration *t* [ms]				
Voltage *u* [%]	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	30.00	2.50	0.94	0.22	
80 > *u* ≥ 70	6.60	0.46	0.32	0.04	
70 > *u* ≥ 40	3.90	0.56	0.23	0.23	
40 > *u* ≥ 5	0.45	0.16	0.07	0.05	
5 > *u*					

TABLE A3.2 | The 95th percentile of voltage dips per year in the transmission networks in France in 2008

Residual	Duration *t* [ms]				
Voltage *u* [%]	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	72	12.3	5	1	
80 > *u* ≥ 70	19	3	2	0	
70 > *u* ≥ 40	14	3	1	1.3	
40 > *u* ≥ 5	2	1	0.25	0	
5 > *u*					

TABLE A3.3 | The average number of voltage dips per year in the transmission networks in France in 2009

Residual	Duration *t* [ms]				
Voltage *u* [%]	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	32.00	2.30	0.86	0.78	
80 > *u* ≥ 70	7.10	0.54	0.40	0.08	
70 > *u* ≥ 40	4.60	0.45	0.33	0.10	
40 > *u* ≥ 5	0.77	0.25	0.11	0.01	
5 > *u*					

TABLE A3.4 | The 95th percentile of voltage dips per year in the transmission networks in France in 2009

Residual Voltage *u* [%]	Duration *t* [ms]				
	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	92	12	3.3	1	
80 > *u* ≥ 70	22	3	3	1	
70 > *u* ≥ 40	14	2	2	1	
40 > *u* ≥ 5	4	1	1	0	
5 > *u*					

TABLE A3.5 | The average number of voltage dips per year in the transmission networks in France in 2010

Residual Voltage *u* [%]	Duration *t* [ms]				
	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	24.00	1.60	0.73	0.11	
80 > *u* ≥ 70	5.40	0.38	0.23	0.05	
70 > *u* ≥ 40	3.30	0.33	0.27	0.15	
40 > *u* ≥ 5	0.42	0.15	0.07	0.01	
5 > *u*					

TABLE A3.6 | The 95th percentile of voltage dips per year in the transmission networks in France in 2010

Residual Voltage *u* [%]	Duration *t* [ms]				
	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	65	9.3	3	1	
80 > *u* ≥ 70	17	1.3	1	0	
70 > *u* ≥ 40	15	1	1.3	1	
40 > *u* ≥ 5	2	1	0.3	0	
5 > *u*					

HUNGARY

Below 2 tables show the average number of voltage dips per measurement location per year in the MV and LV networks in Hungary in 2009.

TABLE A3.7 | The average number of voltage dips per year in the LV network in Hungary in 2009

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
90 > *u* ≥ 80	277.3	100.7	44.8	73.5	90.8
80 > *u* ≥ 70	24.8	4.2	1.7	2.0	0.7
70 > *u* ≥ 40	23.6	2.5	0.7	0.6	0.5
40 > *u* ≥ 10	11.3	1.5	1.1	1.4	1.2
10 > *u*	14.3	2.2	4.2	8.6	5.0

TABLE A3.8 | The average number of voltage dips per year in the MV network in Hungary in 2009

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
90 > *u* ≥ 80	86.3	7.9	4.8	5.1	1.5
80 > *u* ≥ 70	25.2	2.3	1.4	1.1	0.0
70 > *u* ≥ 40	21.2	2.0	1.0	1.2	0.1
40 > *u* ≥ 10	4.9	1.0	0.4	0.2	0
10 > *u*	0	0	0	0	0

ITALY

The 3 tables below show the average number of voltage dips at MV busbars of HV/MV substations in Italy during the period from 2008 up to and including 2010. The data has been obtained from a sample of about 10% of the entire Italian network.

TABLE A3.9 | The average number of voltage dips per year at MV busbars of HV/MV substations in Italy in 2008 (10% sample of the Italian networks)

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
90 > u ≥ 80	29.2	5.6	1.2	0.8	0.2
80 > u ≥ 70	18.6	4.3	0.5	0.1	0.0
70 > u ≥ 40	40.0	6.8	0.6	0.1	0.0
40 > u ≥ 5	15.4	2.6	0.3	0.0	0.0
5 > u	0.2	0.0	0.0	0.0	0.0

TABLE A3.10 | The average number of voltage dips per year at MV busbars of HV/MV substations in Italy in 2009 (10% sample of the Italian networks)

Residual Voltage *u* [%]	Duration *t* [ms]				
	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	34.9	7.5	2.0	0.6	0.0
80 > *u* ≥ 70	17.1	5.3	0.6	0.2	0.0
70 > *u* ≥ 40	28.2	5.3	0.6	0.1	0.0
40 > *u* ≥ 5	9.9	1.7	0.2	0.0	0.0
5 > *u*	0.2	0.0	0.0	0.0	0.0

TABLE A3.11 | The average number of voltage dips per year at MV busbars of HV/MV substations in Italy in 2010 (10% sample of the Italian networks)

Residual Voltage *u* [%]	Duration *t* [ms]				
	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	31.5	6.4	1.6	0.4	0.1
80 > *u* ≥ 70	15.5	4.4	0.5	0.1	0.0
70 > *u* ≥ 40	22.6	4.8	0.4	0.1	0.0
40 > *u* ≥ 5	8.5	1.3	0.2	0.0	0.0
5 > *u*	0.0	0.0	0.0	0.0	0.0

Figures A3.1 through A3.4 below show the distribution of voltage dips at MV busbars of HV/MV substations in Italy [42] [43] during 2009 and 2010, by using the presentation usually referred to as "contour charts". The number associated with each contour refers to the number of dips per year below the residual voltage and over the duration for the points on that contour. For a description of contour charts, see also Case study 12.

FIGURE A3.1 | Distribution of voltage dips in Italy 95%-sites year 2009

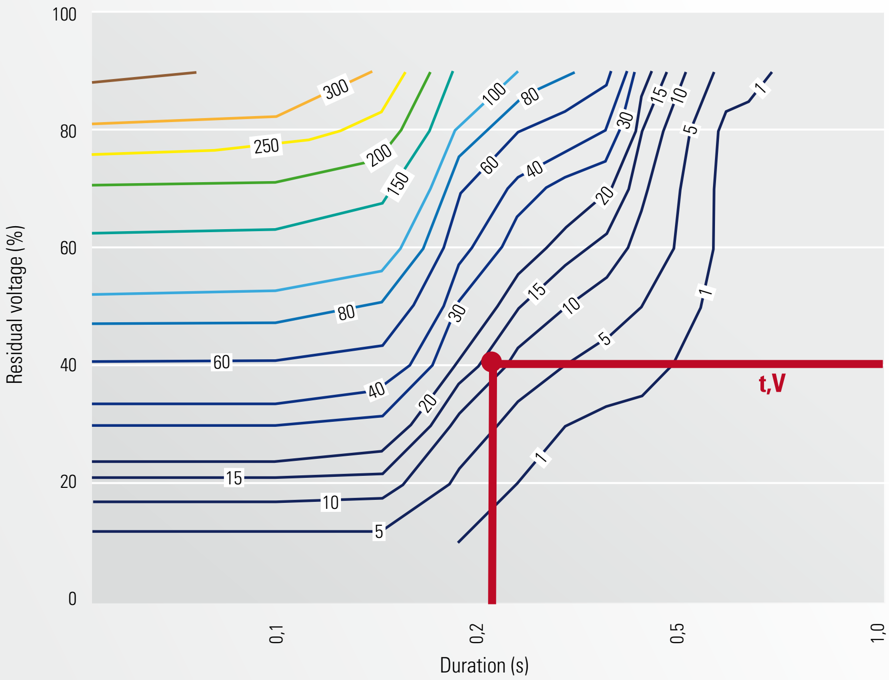


FIGURE A3.2 | Distribution of voltage dips in Italy 50%-sites year 2009

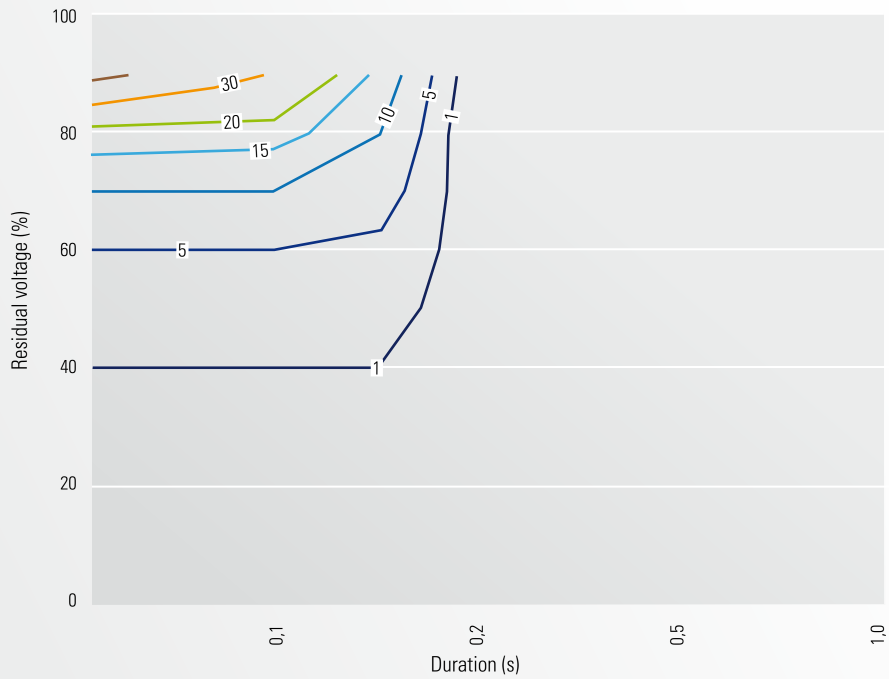


FIGURE A3.3 | Distribution of voltage dips in Italy 95%-sites year 2010

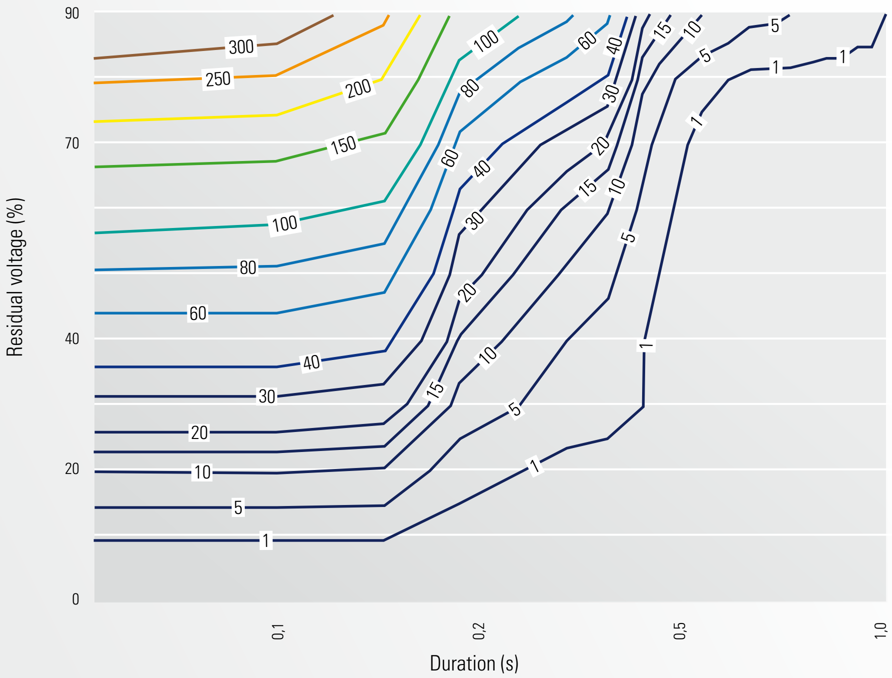


FIGURE A3.4 | Distribution of voltage dips in Italy: 50%-sites year 2010

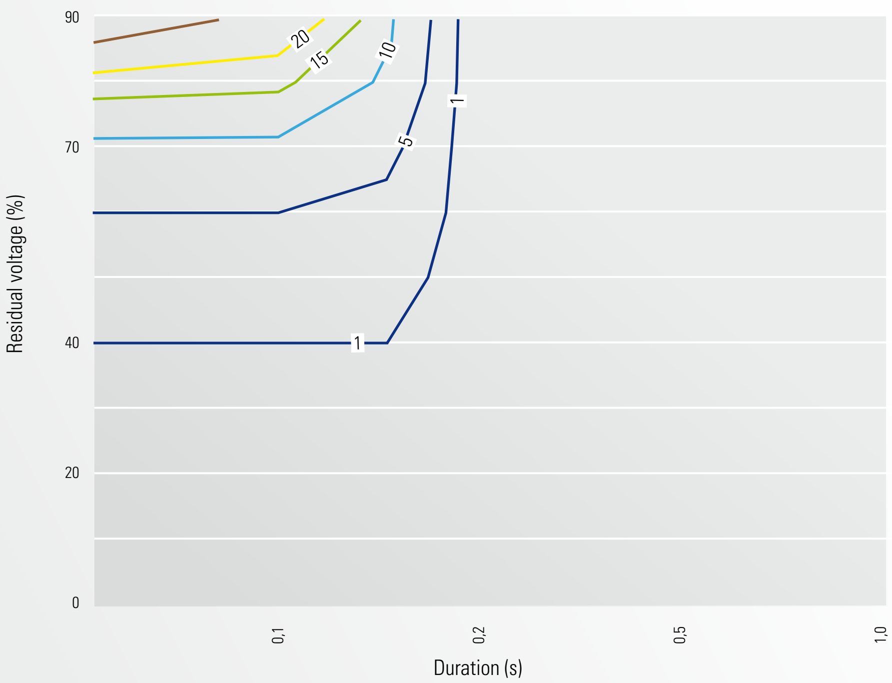


TABLE A3.12 | The average number of voltage dips per year recorded in 90 HV sites (150 kV and 132 kV, excluding EHV sites) in Italy in 2010 - MONO-PHASE dips (above) and POLY-PHASE dips (below)

Residual Voltage *u* [%]	MONO-PHASE Duration *t* [ms]				
	20 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	15.67	0.61	0.10	0.08	0.00
80 > *u* ≥ 70	5.88	0.18	0.04	0.03	0.00
70 > *u* ≥ 40	6.16	0.22	0.03	0.02	0.00
40 > *u* ≥ 5	1.28	0.12	0.01	0.01	0.00
5 > *u*	0.00	0.00	0.00	0.00	0.00

Residual Voltage *u* [%]	POLY-PHASE Duration *t* [ms]				
	20 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	9.27	1.54	0.18	0.09	0.00
80 > *u* ≥ 70	3.30	0.09	0.07	0.01	0.00
70 > *u* ≥ 40	2.79	0.28	0.08	0.01	0.00
40 > *u* ≥ 5	0.97	0.13	0.01	0.00	0.00
5 > *u*	0.00	0.00	0.00	0.00	0.00

THE NETHERLANDS

The 4 tables below show the voltage dip data from The Netherlands for the period from 2007 up to and including 2010. The data has been obtained from measurements at 20 connection points in the HV network. The average number of voltage dips at a single measurement location is provided. For the period 2007 up to and including 2009, the data could not be obtained in the voltage dip table according to the standard EN 50160.

TABLE A3.13 | The average number of voltage dips per year in the HV network in The Netherlands in 2007

<table>
<tr><th rowspan="2">Residual Voltage u [%]</th><th colspan="5">Duration t [ms]</th></tr>
<tr><th>10 ≤ t ≤ 20</th><th>20 ≤ t ≤ 100</th><th>100 < t ≤ 500</th><th>500 < t ≤ 2,500</th><th>2,500 < t ≤ 5,000</th></tr>
<tr><td>90 > u ≥ 80</td><td rowspan="2">0</td><td rowspan="2">4</td><td rowspan="2">1.7</td><td>0.2</td><td>0</td></tr>
<tr><td>80 > u ≥ 70</td><td rowspan="2">0.1</td><td rowspan="2">0</td></tr>
<tr><td>70 > u ≥ 50</td><td rowspan="2">0</td><td rowspan="2">0.4</td><td rowspan="2">0.5</td></tr>
<tr><td>50 > u ≥ 40</td><td rowspan="2">0</td><td rowspan="2">0.2</td></tr>
<tr><td>40 > u ≥ 1</td><td>0</td><td>0.9</td><td>0.5</td></tr>
</table>

TABLE A3.14 | The average number of voltage dips per year in the HV network in The Netherlands in 2008

<table>
<tr><th rowspan="2">Residual Voltage u [%]</th><th colspan="5">Duration t [ms]</th></tr>
<tr><th>10 ≤ t ≤ 20</th><th>20 ≤ t ≤ 100</th><th>100 < t ≤ 500</th><th>500 < t ≤ 2,500</th><th>2,500 < t ≤ 5,000</th></tr>
<tr><td>90 > u ≥ 80</td><td rowspan="2">0.1</td><td rowspan="2">4.1</td><td rowspan="2">1.9</td><td>0.1</td><td>0.1</td></tr>
<tr><td>80 > u ≥ 70</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>70 > u ≥ 50</td><td rowspan="2">0</td><td rowspan="2">0.5</td><td rowspan="2">0.2</td></tr>
<tr><td>50 > u ≥ 40</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>40 > u ≥ 1</td><td>0</td><td>0.5</td><td>0.3</td></tr>
</table>

TABLE A3.15 | The average number of voltage dips per year in the HV network in The Netherlands in 2009

<table>
<tr><th rowspan="2">Residual Voltage u [%]</th><th colspan="5">Duration t [ms]</th></tr>
<tr><th>10 ≤ t ≤ 20</th><th>20 ≤ t ≤ 100</th><th>100 < t ≤ 500</th><th>500 < t ≤ 2,500</th><th>2,500 < t ≤ 5,000</th></tr>
<tr><td>90 > u ≥ 80</td><td rowspan="2">0.1</td><td rowspan="2">4.9</td><td rowspan="2">1.1</td><td>0.3</td><td>0</td></tr>
<tr><td>80 > u ≥ 70</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>70 > u ≥ 50</td><td rowspan="2">0</td><td rowspan="2">0.8</td><td rowspan="2">0.3</td></tr>
<tr><td>50 > u ≥ 40</td><td rowspan="2">0.1</td><td rowspan="2">0</td></tr>
<tr><td>40 > u ≥ 1</td><td>0</td><td>1.1</td><td>0.5</td></tr>
</table>

TABLE A3.16 | The average number of voltage dips per year in the HV network in The Netherlands in 2010

Residual	Duration *t* [ms]				
Voltage *u* [%]	10 ≤ *t* ≤ 200	200 < *t* ≤ 500	500 < *t* ≤ 1,000	1, 000 < *t* ≤ 5,000	5,000 < *t* ≤ 60,000
90 > *u* ≥ 80	4.0	0.3	0.4	0.1	
80 > *u* ≥ 70	1.3	0.3	0.2	0.0	
70 > *u* ≥ 40	0.9	0.1	0.0	0.0	
40 > *u* ≥ 5	0.7	0.0	0.0	0.0	
5 > *u*	0.3	0.0	0.1	0.9	

PORTUGAL

Below are 5 tables with data for the transmission networks (60 and 150 kV) in Portugal during 2007 up to and including 2009. For 2007, only the average number of voltage dips per year is included. For 2007, measurements were performed at 5 connection points. For 2008 and 2009, the number of measurement locations has been increased to 7 locations in the transmission networks. For these locations, both the average number of voltage dips and the highest number of voltage dips at any one location have been included.

TABLE A3.17 | The average number of voltage dips per year in the transmission network (60 kV) in Portugal in 2007

Residual	Duration *t* [ms]					
Voltage *u* [%]	10 ≤ *t* ≤ 100	100 < *t* ≤ 250	250 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 3,000	3,000 < *t* ≤ 20,000
90 > *u* ≥ 80	122	31	14	4	3	0
80 > *u* ≥ 70	23	18	7	1	1	0
70 > *u* ≥ 60	30	12	2	1	1	0
60 > *u* ≥ 50	23	2	1	0	0	0
50 > *u* ≥ 40	15	1	3	1	0	0
40 > *u* ≥ 30	22	0	1	0	0	0
30 > *u* ≥ 20	14	0	0	1	0	0
20 > *u* ≥ 10	3	1	0	0	0	0
10 > *u* ≥ 1	0	0	0	0	0	0

TABLE A3.18 | The average number of voltage dips per year in the transmission network (60 and 150 kV) in Portugal in 2008

Residual Voltage *u* [%]	Duration *t* [ms]						
	10 ≤ *t* ≤ 100	100 < *t* ≤ 250	250 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 3,000	3,000 < *t* ≤ 20,000	20,000 < *t* ≤ 60,000
90 > *u* ≥ 80	14.6	5.9	3.7	0.4	0.4	0.1	0
80 > *u* ≥ 70	6.0	1.6	1.3	1.3	0.6	0	0
70 > *u* ≥ 60	3.9	1.9	0.7	0.3	0.1	0	0
60 > *u* ≥ 50	3.9	1.1	0.3	0	0.3	0	0
50 > *u* ≥ 40	5.9	0.1	0.4	0.3	0	0	0
40 > *u* ≥ 30	4.4	0	0.7	0	0	0	0
30 > *u* ≥ 20	5.6	0.4	0.6	0	0	0	0
20 > *u* ≥ 10	1.4	0	0.1	0.1	0	0	0
10 > *u* ≥ 1	0.6	0	0.1	0.3	0	0.3	0.1

TABLE A3.19 | The highest number of voltage dips at any one particular location of a total of 7 connection points in the transmission network (60 and 150 kV) in Portugal in 2008

Residual Voltage *u* [%]	Duration *t* [ms]						
	10 ≤ *t* ≤ 100	100 < *t* ≤ 250	250 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 3,000	3,000 < *t* ≤ 20,000	20,000 < *t* ≤ 60,000
90 > *u* ≥ 80	24	16	9	2	1	1	0
80 > *u* ≥ 70	19	4	3	7	1	0	0
70 > *u* ≥ 60	13	4	2	1	1	0	0
60 > *u* ≥ 50	9	4	2	0	1	0	0
50 > *u* ≥ 40	21	1	1	1	0	0	0
40 > *u* ≥ 30	18	0	2	0	0	0	0
30 > *u* ≥ 20	28	3	1	0	0	0	0
20 > *u* ≥ 10	6	0	1	1	0	0	0
10 > *u* ≥ 1	4	0	1	2	0	2	1

TABLE A3.20 | The average number of voltage dips at 7 connection points in the transmission network (60 and 150 kV) in Portugal in 2009

Residual Voltage *u* [%]	Duration *t* [ms]						
	10 ≤ *t* ≤ 100	100 < *t* ≤ 250	250 < *t* ≤ 500	500 < *t* ≤ 1,000	1,000 < *t* ≤ 3,000	3,000 < *t* ≤ 20,000	20,000 < *t* ≤ 60,000
90 > *u* ≥ 80	17.7	10.1	1.6	0.6	1.6	0.6	0
80 > *u* ≥ 70	7.4	3.6	0.9	1.6	0.3	0	0
70 > *u* ≥ 60	4.0	2.7	0.7	1.9	0.3	0.4	0
60 > *u* ≥ 50	3.9	0.9	0.7	0.4	0.1	0.3	0
50 > *u* ≥ 40	3.4	0.1	0	0	0.3	0.1	0
40 > *u* ≥ 30	2.6	0.6	0.1	0.1	0.1	0	0
30 > *u* ≥ 20	1.6	0.3	0.6	0	0	0	0
20 > *u* ≥ 10	1.7	0	0.1	0	0	0	0
10 > *u* ≥ 1	0.3	0	0	0.1	0	0	0

TABLE A3.21 | The highest number of voltage dips at any one particular location of a total of 7 connection points in the transmission network (60 and 150 kV) in Portugal in 2009

Residual Voltage u [%]	Duration t [ms]						
	$10 \leq t \leq 100$	$100 < t \leq 250$	$250 < t \leq 500$	$500 < t \leq 1{,}000$	$1{,}000 < t \leq 3{,}000$	$3{,}000 < t \leq 20{,}000$	$20{,}000 < t \leq 60{,}000$
$90 > u \geq 80$	35	21	4	2	6	3	0
$80 > u \geq 70$	20	8	2	6	2	0	0
$70 > u \geq 60$	9	5	2	7	1	2	0
$60 > u \geq 50$	10	2	2	1	1	1	0
$50 > u \geq 40$	7	1	0	0	1	1	0
$40 > u \geq 30$	7	1	1	1	1	0	0
$30 > u \geq 20$	4	2	3	0	0	0	0
$20 > u \geq 10$	5	0	1	0	0	0	0
$10 > u \geq 1$	2	0	0	1	0	0	0

SLOVENIA

The 10 tables below show the voltage quality data from Slovenia for 2008 and 2009 for both the DSOs (HV and MV networks) and the TSO. Figure A3.5 shows the 5 distribution areas of the DSOs in Slovenia.

FIGURE A3.5 | A schematic map of the distribution areas of the five DSOs in Slovenia

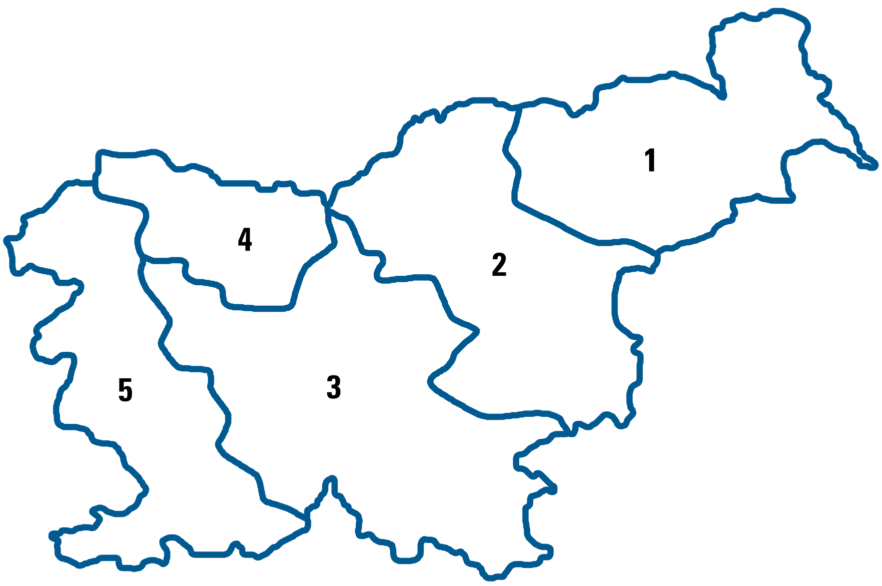


TABLE A3.22 | Voltage quality data in the HV network (110 kV) in Slovenia in 2008

Network area	Voltage quality non-conformance index [%]					
	Supply voltage variations	Harmonic voltage	Flicker	Voltage unbalance	Mains signalling voltage	Power frequency
Distribution area 1	0.0	0.0	0.0	0.0	0.0	0.0
Distribution area 2	0.0	0.0	25.6	0.0	0.0	0.0
Distribution area 3	0.0	0.0	0.4	0.0	0.0	0.0
Distribution area 4	0.0	0.0	94.6	0.0	0.0	0.0
Distribution area 5	0.0	0.0	0.0	0.0	0.0	0.6

TABLE A3.23 | Voltage quality data in the HV network (110 kV) in Slovenia in 2009

Network area	Voltage quality non-conformance index [%]					
	Supply voltage variations	Harmonic voltage	Flicker	Voltage unbalance	Mains signalling voltage	Power frequency
Distribution area 1	0.0	0.0	0.0	0.0	0.0	0.0
Distribution area 2	0.0	0.0	23.1	0.0	0.0	0.0
Distribution area 3	0.0	0.0	5.4	0.0	0.0	0.0
Distribution area 4	0.0	0.0	86.7	0.0	0.0	0.0
Distribution area 5	0.3	0.0	0.1	0.0	0.0	0.6

TABLE A3.24 | Voltage quality data in the MV networks (10, 20 and 35 kV) in Slovenia in 2008

Network area	Voltage quality non-conformance index [%]					
	Supply voltage variations	Harmonic voltage	Flicker	Voltage unbalance	Mains signalling voltage	Power frequency
Distribution area 1	0.0	1.1	0.0	0.0	0.0	0.0
Distribution area 2	0.0	0.0	21.9	0.0	0.0	0.0
Distribution area 3	0.1	1.9	3.6	0.0	0.0	0.0
Distribution area 4	0.3	0.4	32.9	4.0	0.0	0.1
Distribution area 5	0.4	0.0	0.1	0.1	0.0	1.0

TABLE A3.25 | Voltage quality data in the MV networks (10, 20 and 35 kV) in Slovenia in 2009

Network area	Voltage quality non-conformance index [%]					
	Supply voltage variations	Harmonic voltage	Flicker	Voltage unbalance	Mains signalling voltage	Power frequency
Distribution area 1	0.0	2.7	0.0	0.0	0.0	0.0
Distribution area 2	0.0	0.0	19.1	0.0	0.0	0.0
Distribution area 3	0.0	0.1	4.5	0.1	0.0	0.0
Distribution area 4	0.0	0.0	41.5	0.0	0.0	0.0
Distribution area 5	0.1	0.0	0.1	0.0	0.0	0.1

TABLE A3.26 | The number of voltage dips and swells in the HV network (110 kV) in Slovenia in 2008

Network area	Total number of voltage dips and voltage swells	
	Voltage dips	Voltage swells
Distribution area 1	697	6
Distribution area 2	1,124	3,552
Distribution area 3	1,610	6
Distribution area 4	480	178
Distribution area 5	1,345	66

TABLE A3.27 | The number of voltage dips and swells in the HV network (110 kV) in Slovenia in 2009

Network area	Total number of voltage dips and voltage swells	
	Voltage dips	Voltage swells
Distribution area 1	683	5
Distribution area 2	911	6,621
Distribution area 3	1,201	15
Distribution area 4	412	209
Distribution area 5	1,127	100

TABLE A3.28 | The number of voltage dips and swells in the MV networks (10, 20 and 35 kV) in Slovenia in 2008

Network area	Total number of voltage dips and voltage swells	
	Voltage dips	Voltage swells
Distribution area 1	1,937	56
Distribution area 2	6,655	18,781
Distribution area 3	6,778	70
Distribution area 4	2,249	16,917
Distribution area 5	4,999	3,855

TABLE A3.29 | The number of voltage dips and swells in the MV networks (10, 20 and 35 kV) in Slovenia in 2009

Network area	Total number of voltage dips and voltage swells	
	Voltage dips	Voltage swells
Distribution area 1	3,230	59
Distribution area 2	4,112	6,569
Distribution area 3	5,850	109
Distribution area 4	1,659	7,809
Distribution area 5	4,308	3,208

TABLE A3.30 | Voltage quality data in the transmission network of the TSO in Slovenia in 2008 and 2009

Year	Voltage quality non-conformance index [%]					
	Supply voltage variations	Harmonic voltage	Flicker	Voltage unbalance	Mains signalling voltage	Power frequency
2008	0.1	0.0	14.5	0.0	0.0	0.0
2009	0.1	0.0	12.2	0.1	0.0	0.0

TABLE A3.31 | The number of voltage dips and swells in the transmission network of the TSO in Slovenia in 2008 and 2009

Year	Total number of voltage dips and voltage swells	
	Voltage dips	Voltage swells
2008	1,196	18,606
2009	3,096	23,985

Annex to Chapter 4 on Commercial Quality

Annex to Chapter 4 on Commercial Quality presents detailed information on commercial quality in the countries surveyed. First, it includes a set of 17 tables referring to the features of regulating each of 15 performances and 2 sub-performances (II.6a and II.6b) listed in Table 4.1 (Part 1 of the Annex to Chapter 4 - commercial quality regulation). Next, it presents the set of corresponding 17 tables which display the actual data in 2008, 2009, 2010, when available (Part 2 of the Annex to Chapter 4 - commercial quality data).

The tables use the same numbering of commercial quality indicators presented in Table 4.1, e.g. Table A4.1.1 and Table A4.2.1 refer to the indicator I.1 "Time for response to customer claim for network connection".

As data might not be available in all countries, the tables in Part 2 of the Annex to Chapter 4 can be shorter than the tables in Part 1 of the Annex to Chapter 4. When tables in Part 2 of the Annex to Chapter 4 display the same country more than once (which might be the case when presenting a country's actual data for LV customers and actual data for MV customers), the reader is referred to the corresponding table in Part 1 of the Annex to Chapter 4 to understand the reason for this double posting.

Part 1 of the Annex to Chapter 4 – Commercial quality regulation

TABLE A4.1.1 | Time for response to customer claim for network connection

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	14	days	100				DSO	LV	
CZECH REPUBLIC	GS	30	days		25 (max. 2,500)	Upon claim		DSO	LV	i.
ESTONIA	OS	30	days	100				DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
GREAT BRITAIN	GS	10/20	wd		50	Cheque		DSO		ii.
GREECE	OAR	15/20	days					DSO	LV	
GREECE	OAR	20	days					DSO	MV	
HUNGARY	GS	8	days	100	18	Automatic		DSO	LV	
HUNGARY	OAR	8	days	100				DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
SLOVAK REPUBLIC	OAR	30	days					DSO	LV	
SLOVENIA	GS	8	days					DSO		
SPAIN	GS	15	days		30	Discount in the bill		DSO		
LATVIA	OS	15	days	90				DSO	LV	

i. LV (30 days, 25€, max. 500€), MV (30/60 days, 50€, max. 5,000€), HV (30/60 days, 500€, max. 25,000€).
ii. A budget estimate is to be provided depending on the size of the connection less than 1 MVA by 10 working days, 1 MVA or greater is by 20 working days.

TABLE A4.1.2 | Time for cost estimation for simple works

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	14	days	100				DSO	LV	
ESTONIA	OS	30	days	100				DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
FRANCE	GS	10	wd		30	Upon claim		DSO	LV	
GREAT BRITAIN		5/15/25	wd	0		Cheque		DSO	LV	i.
GREECE	OAR	15	days					DSO	LV	
GREECE	OAR	20	days					DSO	MV	
HUNGARY	GS	8	days	100	18	Automatic		DSO	LV	
HUNGARY	OAR	8	days	100				DSO	LV	
IRELAND	GS	7/15/90	wd	100				DSO		ii.
ITALY	GS	20	wd	NA	30	Automatic	iii.	DSO	LV	
ITALY	GS	15	wd	NA	30	Automatic	iv.	DSO	LV	
THE NETHERLANDS	OAR	10	wd					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
PORTUGAL	OS	20	wd	95				DSO	LV	
SLOVENIA	OAR	10	wd					DSO	LV	
SPAIN	GS	5	days		30	Discount in the bill		DSO	LV	v.

i. Dependent on size of connection: 5 working days for single LV service demand connection, or 15 working days for a small project demand connection, or 25 days for an LV demand connection other than single LV service demand connections and small project.
ii. 7 working days when no visit to site is required; 15 working days when a visit to site is required; for connections to larger developments or connections over 100 kW or Medium Voltage connections the standard is 90 working days.
iii. This is the standard applicable to cost estimation for simple works. Note that the automatic compensation doubles after 40 working days and is triple after 60 working days.
iv. This is the standard applicable to execution of simple works Note that the automatic compensation doubles after 30 working days and becomes triple after 45 working days.
v. 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.

TABLE A4.1.3 | Time for connecting new customers to the network

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	14	days	100				DSO	LV	
CZECH REPUBLIC	GS	5	wd	not appl.	250 (max. 2,500)	Upon claim	N/A	DSO	LV	i.
ESTONIA	OM	Within reasonable time						DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
FRANCE	OM							DSO	LV	ii.
GREAT BRITAIN	GS	25/35/65		0	50	Cheque		DSO		iii.
GREECE	OAR	15/30/75/100	days					DSO	LV	
GREECE	OAR	20/40/100	days					DSO	MV	
HUNGARY	GS	8	days	100	18	Automatic		DSO	LV	
HUNGARY	OAR	8	days	100				DSO	LV	
IRELAND	GS	2	weeks	100	65			DSO		iv.
ITALY	GS	5	wd	NA	30	Automatic	Doubles after 10, triples after 15 working days	DSO	LV	v.
ITALY	GS	5	wd	NA	120	Automatic	Doubles after 10, triples after 15 working days	DSO	MV	
THE NETHER-LANDS	OAR	18	weeks					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
PORTUGAL	OS	2	wd	90				DSO	LV	
SLOVAK REPUBLIC	OAR	5	wd					DSO	LV	
SLOVENIA	OAR	20	wd	95				DSO	LV	
SPAIN	GS	6-80	days		30			DSO	LV	According to complexity
LATVIA	OS	Within reasonable time						DSO	LV	

i. LV (5 work days, 250 €, max. 2,500 €), MV, HV (5 work days, 500 €, max. 5,000 €).
ii. Date agreed with customer.
iii. Similar to I.2 "Time for cost estimation for simple works" but beyond this, LV, HV and EHV demand connections. 25 working days for LV, 35 working days for HV, 65 working days for EHV.
iv. Provided the connection has been applied and paid for at least 10 weeks prior to the completion of the electrical installation, the DSO will complete the new connection within 2 weeks of receipt of the Electro Technical Council of Ireland Completion Certificate.
v. Data here are related only to the performance "activation of supply without interventions outside the meter". Other types of connection, which include works, are subject to two different standards: i) cost estimation and ii) execution of works.

TABLE A4.1.4 | Time for disconnection upon customer's request

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
ESTONIA	OS	5-8	wd	100				DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
FRANCE	OM	5	wd					DSO	LV	
IRELAND	OM	5	wd	100				DSO		De-energisation within 5 days
ITALY	GS	5	wd	NA	30	Automatic	Doubles after 10, triples after 15 working days	DSO	LV	
ITALY	GS	7	wd	NA	120	Automatic	Doubles after 14, triples after 21 working days	DSO	MV	
NORWAY	OAR	Within reasonable time						DSO		
LATVIA	OS	5	days					DSO	LV	

TABLE A4.1.5 | Punctuality of appointments with customers

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	1	hours		100	Upon claim		DSO	LV	In 2010 change of methodology
ESTONIA	OS	30	minutes					DSO	LV	30 for domestic customers, 15 for business customers
FRANCE	GS				24	Upon claim		DSO	LV	
GREAT BRITAIN	GS	Within reasonable time			22	Cheque		DSO	LV	
HUNGARY	GS	4	hours	100	18	Automatic		DSO	LV	
IRELAND	GS			100	35		35 per case	DSO		i.
ITALY	GS	2	hours	NA	30	Automatic	-	DSO	LV	
THE NETHERLANDS	OAR	2	hours					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
PORTUGAL	GS	2.5	hours	100	18	Automatic		DSO	LV	ii.
PORTUGAL	GS	2.5	hours	100	30	Automatic		DSO	MV	ii.
SLOVENIA	OAR	3	hours					DSO		

i. Visit as agreed or rearranged the day before the appointment should a problem arise.

ii. Whenever the customer fails to be present at the appointment, a compensation is due to the DSO. The amounts are: 9€ for LV customers, 30€ for MV and 92€ for HV.

TABLE A4.1.6 | Response time to customer complaints and enquiries (Including voltage issues and interruptions)

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
ESTONIA	OS							DSO	LV	
ESTONIA	OS							SP	LV	
FINLAND	OAR	Within reasonable time						DSO		
FRANCE	OS	30	days	95			100,000€ per full point below 95%	DSO	MV	i.
GREAT BRITAIN	GS	5-7	wd		22	Cheque		DSO	LV	
HUNGARY	GS	15	days	100	18	Automatic		DSO	LV	
HUNGARY	GS	15	days	100	18	Automatic		SP	LV	
HUNGARY	OS	15	days	100			370,000	DSO	LV	
HUNGARY	OS	15	days	100			370,000	SP	LV	
ITALY	OS	20	wd	90	NA	NA	NA	DSO	LV	
ITALY	GS	10-15	wd		20	Automatic to the supplier	-	DSO	LV	ii.
ITALY	GS	40	days		20	Automatic (max once per year)	NA	SP	LV	iii.
THE NETHERLANDS	OAR	10	wd					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		iv.
PORTUGAL	OS	15	wd	90				DSO		v.
PORTUGAL	OS	15	wd	90				USP		
SLOVENIA	GS	15	days					DSO		
SPAIN	GS	5	days		30	Discount in bill		DSO	LV	
LATVIA	OS	15	days					DSO	LV	

i. No distinction between voltage issues (Table A4.1.6a below) and interruptions (Table A4.1.6b below). Applies to both MV and LV networks.
ii. The standard refers to claims of LV customers forwarded by the supplier. Time is differentiated depending on the activities needed for the reply: 10 working days if only meter reading (15 working days in other cases).
iii. The data here refers only to complaints excluding questions in relation with costs and payments.
iv. Regarding complaints: VQ and CoS: First answer within 1 month, and within 4 months the network company shall have detected who is responsible for rectifying the problem. Regarding enquiries: Data on VQ and CoS: Within 1 month.
v. Response time to customer complaints and enquiries this, in Portugal, is an OS and concerns only enquiries. The # of cases presented for LV are the totals for all voltage levels, since there is no discrimination of # of cases by LV and MV. The difference presented here is in the compensation value (see duplicate part).

TABLE A4.1.6a | Time for answering the voltage complaint

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Re-marks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	60	days	NA	50 (max. 1,250)	Upon claim	NA	DSO	LV	
ESTONIA	OS							DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
GREAT BRITAIN	GS	5-7	wd		22	Cheque		DSO	LV	
HUNGARY	GS	10	wd	100	18	Automatic		DSO	LV	
THE NETHERLANDS	OAR	10	wd					DSO	LV	
NORWAY	OAR							DSO		
PORTUGAL	GS	15	wd	100	18	Automatic		DSO	LV	
PORTUGAL	GS	15	wd	100	30	Automatic		DSO	MV	
SLOVAK REPUBLIC	OAR	30	days					DSO	LV	
SLOVENIA	GS	15	days					DSO		
SPAIN	GS	5	days		30	Discount in bill		DSO	LV	
LATVIA	OS	15	days					DSO	LV	

TABLE A4.1.6b | Time for answering the interruption complaint

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
ESTONIA	OS							DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
THE NETHERLANDS	OAR	10	wd					DSO	LV	
NORWAY	OAR							DSO		
PORTUGAL	GS	15	wd	100		Automatic		DSO		i.
PORTUGAL	GS	15	wd	100		Automatic		USP		i.
SLOVENIA	GS	15	days					DSO		
SPAIN	GS	5	days		30	Discount in bill		DSO	LV	
LATVIA	OS	15	days					DSO	LV	

i. The GS used in Mainland Portugal for complaints addresses all complaint's subjects (except for voltage complaints and metering, which are separated GS and are presented here in the "Time for answering the interruption complaint" area, both for DSO and USP.

TABLE A4.1.7 | Response time to questions in relation to costs and payments (excluding connection)

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	15/30	days		25 (max. 1,000)	Upon claim		DSO	LV	Settlement of payment differences
ESTONIA	OS	5	days	100				DSO	LV	
ESTONIA	OM	5	days					SP	LV	
FINLAND	OAR	Within reasonable time						DSO		
ITALY	OS	40	days	95				SP	LV	i.
THE NETHERLANDS	OAR	10	wd					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
SLOVAK REPUBLIC	OAR	30	days					DSO	LV	
SLOVENIA	GS	8	wd					DSO		
SPAIN	OS	5	days		30	Discount in bill		DSO	LV	
LATVIA	OS	15	days					DSO	LV	

i. The data here refers to the "correction of billing and payment mistakes". Another standard exists (not reported here) for correction of double bills due to switching among different suppliers.

TABLE A4.1.8 | Time between the date of the answer to the VQ complaint and the elimination of the problem

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	1/6/24	months		50 (max. 2,500)	Upon claim	NA	DSO	LV	i.
ESTONIA								DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
HUNGARY	GS	1	year	100	18	Automatic		DSO	LV	ii.
IRELAND	GS	12	weeks	100	50			DSO		
NORWAY	OAR	Without undue delay						DSO		

i. 30 days, 6 month, 24 month (building permit needed).
ii. Subsequent to the first year, the frequency of compensation payment grows (once in the first year, later quarterly and finally monthly).

TABLE A4.1.9 | Time until the start of the restoration of supply following failure of fuse of DSO

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	4-6	hour		50	Upon claim	NA	DSO	LV	4 in Prague
ESTONIA								DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
GREAT BRITAIN	GS	3	hour	0	22	Incentive scheme mechanism		DSO		
HUNGARY	GS	4	hour	100	18	Automatic		DSO	LV	i.
IRELAND	GS	3	hour	100	35			DSO		
ITALY	GS	4	hour	NA	30	Automatic	Doubles and triples as above	DSO	LV	ii.
NORWAY	OAR	Without undue delay						DSO		
PORTUGAL	GS			100		Automatic		DSO		iii.
SLOVENIA	GS	1	day					DSO		
LATVIA	OAR	4	hour					DSO	LV	

i. The lead time depends on the size of the village and on the day of the week (weekday or weekend), e.g. for villages with less than 5,000 inhabitants the standard for restoration during weekend days is 12 hours.
ii. Advance notice also applies to MV (identical).
iii. 3 hours for customers dependent on medical equipment; 5 hours for customers in areas classified as "C" (rural areas); 4 hours for all other customers. If the customer is responsible for the fault, he could have to pay the DSO compensation.

TABLE A4.1.10 | Time for giving information in advance of a planned interruption

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	48	hour	100				DSO	LV	
CZECH REPUBLIC		15	days					DSO		i.
ESTONIA	OS	2	wd	100				DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
GREAT BRITAIN	GS	2	wd	0	22	Cheque		DSO		
HUNGARY	GS	15	days	100	18	Automatic		DSO	LV	ii.
IRELAND	GS	2	days	100				DSO		
ITALY	OAR	1-2	days					DSO		
THE NETHERLANDS	OAR	3	wd					DSO	LV	
NORWAY	OAR	Within reasonable time						DSO		
SLOVAK REPUBLIC	OAR	15	days					DSO	LV	
SLOVENIA	GS	48	hour					DSO		
SPAIN	GS	24	hour		30	Discount in bill		DSO		iii.
SWEDEN	OAR	Within reasonable time						DSO		
LATVIA	OS	5	days					DSO	LV	

i. 15 days for DSOs according to the Energy law, 50 days for TSO.
ii. For customers consuming more than 200kVA the standard is 30 days.
iii. All interruptions must be informed to public administration within 72 hours in advance.

TABLE A4.1.11 | Time until the restoration of supply in case of unplanned interruption

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	12-18	hour		10 % of the customer's annual distribution charge	Upon claim		DSO	LV	i.
ESTONIA	OS	12-16	hour					DSO	LV	
FINLAND	OAR	Within reasonable time						DSO		
GREAT BRITAIN								DSO		
HUNGARY	GS	12	hour	100	18	Automatic		DSO	LV	ii.
IRELAND	GS	24	hour	100				DSO		
ITALY	GS	8-16	hour	NA	30	Automatic		DSO	LV	iii.
THE NETHERLANDS	GS	4	hour			Automatic, in first bill		DSO	LV	
THE NETHERLANDS		2	hour			Automatic, in first bill		DSO		
THE NETHERLANDS	GS	1	hour			Automatic, in first bill		DSO		
NORWAY	OAR	Without undue delay						DSO		
PORTUGAL	OS	4	hour	90				DSO		
SLOVAK REPUBLIC	OAR	18-24	hour					DSO	LV	iv.
SLOVENIA	OAR	3	hour					DSO		v.
SWEDEN	GS	12	hour		100			DSO		vi.
SWEDEN	OAR	24	hour					DSO		Electricity law
LATVIA	OS	24	hour					DSO	LV	

i. LV: (18, 12 in Prague city), MV, HV (12, 8 in Prague city).
ii. In case of multiple simultaneous interruptions the standard is 18 hours.
iii. 130,000 violations (automatic compensation) during 2010 for LV customers; 500 non-fulfilments (automatic compensations) during 2010 for MV customers, for which the standards are 4-6-8 hours (see continuity of supply).
iv. 24 hours up to 1 kV, 18 hours above 1 kV.
v. 85% of customers/3 hours and 100% of customers/24 hours.
vi. The compensation depends on the duration of the interruption and on the "estimated annual network tariff". 12-24 hours: 12.5% of estimated annual network tariff, but at least 900 Swedish crowns (about 100€).
Every additional 24 hours: 25% of estimated annual network tariff, but at least 900 Swedish crowns. Maximum 300% of estimated annual network tariff.

TABLE A4.1.12 | Time for meter inspection in case of meter failure

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
CZECH REPUBLIC	GS	15-60	days		25 (max. 1,000)	Upon claim		DSO	LV	change of GS
ESTONIA	OS	5	wd					DSO	LV	
ESTONIA	OS	5	wd					MO	LV	
FINLAND	OAR	Within reasonable time						DSO		
HUNGARY	GS	15	days	100	18	Automatic		DSO	LV	
IRELAND	OM	5	days	95				DSO		
ITALY	GS	15	wd		30	Automatic	Doubles after 30, triples after 45 working days	MO	LV	i.
THE NETHERLANDS	OAR	2	wd					DSO	LV	
THE NETHERLANDS	OAR	2	wd					MO	LV	
SLOVAK REPUBLIC	OAR	30	days					DSO	LV	
SLOVENIA	OAR	10	wd					DSO		
LATVIA	OS	7	wd					DSO	LV	

i. The standard applies for the communication of results after the check of possible meter malfunctioning. It is applicable also for MV customers (15 working days). No data available for MV.

TABLE A4.1.13 | Time from notice to pay until disconnection

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify		
AUSTRIA	OS	14	days	100	No, unless bilateral agreement			DSO	LV
ESTONIA	OS	15	days					DSO	LV
FINLAND	OAR							DSO	
FRANCE		10	wd					DSO	LV
NORWAY	OAR	28	days					DSO	
SLOVENIA	GS	8	days					DSO	
SWEDEN	OAR	3	weeks					DSO and SP	
LATVIA	OS	20	days					DSO	LV

TABLE A4.1.14 | Time for restoration of power supply following disconnection due to non-payment

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	1	wd	100	No, unless bilateral agreement			DSO	LV	Change of GS
CZECH REPUBLIC	GS	2	wd		50	Upon claim		DSO	LV	i.
ESTONIA	OM	8	wd					DSO	LV	
ESTONIA	OM	8	wd					SP	LV	
FINLAND	OAR	Within reasonable time						DSO		
HUNGARY	GS	24	hours	100	18	Automatic		DSO	LV	
HUNGARY	GS	24	hours	100	18	Automatic		SP	LV	
IRELAND	OM	5	days	95				DSO		
ITALY	GS	1	wd		30	Automatic	Doubles after 2, triples after 3 working days	MO	LV	ii.
NORWAY	OAR	Within reasonable time						DSO		
PORTUGAL	GS			100		Automatic		DSO		iii.
SLOVAK REPUBLIC	OAR	3	wd					DSO	LV	
SLOVENIA	OAR	1	wd					DSO		
LATVIA	OS	5	days					DSO	LV	

i. LV (50€, max. 1,250€), MV, HV (150€, max. 3,750€).

ii. The standard does not apply to working days (wd), i.e. non-public holiday days from Monday to Friday, but it is applicable to days from Monday to Saturday. It is applicable also for MV customers. No data available for MV.

iii. Until 5 pm of the next day after regularisation by the LV customer; 8 hours after the regularisation by MV and HV customer.

TABLE A4.1.15 | Yearly number of meter readings by the designated company

Country	Type of requirement	Standard			Compensation in case of non-performance of GS		Penalty or other consequence	Company it refers to? (DSO, SP, USP, MO)	LV or MV	Remarks
	OS, GS, OAR, OM	Quantity	Unit	% of cases	Sum in EUR	Payment method	Sum in EUR or specify			
AUSTRIA	OS	1	year	100	No, unless bilateral agreement			DSO	LV	i.
ESTONIA	OM							DSO	LV	
ESTONIA								MO	LV	
FINLAND	OAR	Daily, monthly or yearly						DSO		Depends on type of metering
FRANCE	OM	1						DSO	LV	
HUNGARY	OAR	1	pc					DSO	LV	
IRELAND	OM	4	per year	97				DSO		
ITALY	OAR							MO	LV	ii.
THE NETHERLANDS	OAR	1	per 3 years					DSO	LV	
THE NETHERLANDS	OAR	1	per 3 years					MO	LV	
NORWAY	OAR	1-12	times					DSO		
PORTUGAL	GS	2	per year	100		Automatic		DSO	LV	
SLOVENIA	OAR	1	year/month					DSO		
SWEDEN	OAR	12	times					DSO		iii.
LATVIA	OAR	1	per year					DSO	LV	

i. Meter readings by DSO obligatory once in 3 years but the general terms and conditions foresee also a yearly self-reading possibility for customers.
ii. 1 reading/year below 30 kW - 1 reading/month above 30 kW (only customers served by the universal service provider, not applicable for "market" customers).
iii. According to the electricity law, meter reading shall take place once per month for customers with a subscription up to 3 x 63 A and once per hour for all other customers.

Part 2 of the Annex to Chapter 4 – Commercial quality data

TABLE A4.2.1 | Time for response to customer claim for network connection

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	184,747	99.6		180,937	99.5		161,200	99.4	9
ESTONIA	OS							3,150	99	9
GREECE	OAR	86,338	89.7	11	73,697	96.63	8			
GREECE	OAR	500	74	24	396	84.34	17			
HUNGARY	GS	125,344	89.79	6.03	92,255	97.71	2.16	84,632	99.4	1.13
HUNGARY	OAR	125,344	89.79	6.03	92,255	97.71	2.16	84,632	99.4	1.13
SLOVAK REPUBLIC	OAR				75,592	97.3		42,368	98	

TABLE A4.2.2 | Time for cost estimation for simple works

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
ESTONIA	OS							1,500	100	5
FRANCE	GS							187,595	86.9	8.3
GREECE	OAR	71,061	93.2	9	60,008	98.46	6			
GREECE	OAR	20	60	27	28	82.14	23			
HUNGARY	GS	125,344	89.79	6.03	92,255	97.71	2.16	84,632	99.4	1.13
HUNGARY	OAR	125,344	89.79	6.03	92,255	97.71	2.16	84,632	99.4	1.13
IRELAND	GS		95			98			99	
ITALY	GS	341,620	98.5	9.82	356,021	99.8	9.65	354,869	99.6	9.88
ITALY	GS	358,022	98.6	7.76	358,975	99.8	7.05	341,867	99.8	7.17
PORTUGAL	OS	70,931	99.88	5.3	60,096	99.89	5.4	50,240	99.97	4.9
SLOVENIA	OAR			10.2			12.5			8.25

TABLE A4.2.3 | Time for connecting new customers to the network

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	185,697	100		178,449	99.4		159,435	100	2.5
ESTONIA	OM							2,360		93
FRANCE	OM							155,220	86.1	39.2
GREECE	OAR	79,741	89.68	15	66,122	97.42	10			
GREECE	OAR	428	83.64	34	332	91.27	25			
HUNGARY	GS	66,420	85.08	6.3	56,742	78.39	8.19	45,510	85.28	
HUNGARY	OAR	66,420	85.08	6.3	56,742	78.39		45,510	85.28	
IRELAND	GS		95			98			98	
ITALY	GS	1,561,276	99.6	1.17	1,576,074	99.9	1.08	1,506,680	99.9	1.03
ITALY	GS	787	85.8	7.22	854	95.5	3.42			3.11
PORTUGAL	OS	209,096	99	2.8	204,408	98.6	3	199,886	98.9	2.1
SLOVAK REPUBLIC	OAR				39,209	92.3		38,259	97	
SLOVENIA	OAR			4.56			5.65			5.25

TABLE A4.2.4 Time for disconnection upon customer's request

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
ESTONIA	OS							26		
FRANCE	OM								98.3	
IRELAND	OM		95			80			88	
ITALY	GS	840,114	99.5	1.25	810,912	99.9	1.26	809,533	99.8	1.14
ITALY	GS	1,348	87.1	8.01	1,967	98.4	5.04			3.87

TABLE A4.2.5 Punctuality of appointments with customers

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS							251,913	99.9	0
GREAT BRITAIN	GS	15,970	0.98		40,309	0.69		0	0	0
HUNGARY	GS	297,003	85.26		409,071	92.7		338,755	96.3	
ITALY	GS	52,605	99.3	NA	74,512	99.4	NA	73,122	98.6	NA
PORTUGAL	GS	738,156	99.95		778,211	99.86		163,710	99.94	
SLOVENIA	OAR			2.18			2.18			2.18

TABLE A4.2.6 | Response time to customer complaints and enquiries (including voltage issues and interruptions)

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
ESTONIA	OS							172,000		
FRANCE	OS							259,063	98.3	
GREAT BRITAIN	GS	3,933	0.12		3,741	0.13		0	0	0
HUNGARY	GS	693,207	99	3.42	819,284	98.5	2.55	1,215,334	99.6	2.41
HUNGARY	GS	770,935	91.88	8.1	1,128,792	93.56	4.77	1,376,265	99.21	3.84
HUNGARY	OS	693,207	99	3.42	819,284	98.5	2.55	1,215,334	99.6	2.41
HUNGARY	OS	770,935	91.88	8.1	1,128,792	93.56	4.77	1,376,265	99.21	3.84
ITALY	OS			15.49			12.09			12.92
ITALY	GS							59,818	98.4	9.54
ITALY	GS							204,144	91.5	22.87
PORTUGAL	OS	3,766	93.1	3.6	4,438	94	4.2	122,121	98	0.46
PORTUGAL	OS	52,410	96.3		52,278	96.1	2.35	1,394,286	99.6	0.26

TABLE A4.2.6a | Time for answering the voltage complaint

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	2,164	96.8		2,311	96.7		2,613	98.3	31
GREAT BRITAIN	GS	3,933	0.12		3,741	0.13		0	0	0
HUNGARY	GS	1,834	88.71		1,199	87.89		907	79.27	
PORTUGAL	GS	5,871			9,548			10,461		
SLOVAK REPUBLIC	OAR				116	94		165	100	

TABLE A4.2.6b | Time for answering the interruption complaint

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
PORTUGAL	GS	38,485	97.9	7.7	46,050	98.93	8.3	43,222	98.99	8.5
PORTUGAL	GS	22,543	98.02	7.4	31,120	98.99	7.4	28,467	98.24	8

TABLE A4.2.7 | Response time to questions in relation to costs and payments (excluding connection)

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	15,842	99.3		15,284	97.8		25,307	98.4	9
ESTONIA	OS							333,000	100	
ITALY	OS							73,701	86.5	28.62
SLOVAK REPUBLIC	OAR				10,297	88.8		7,151	99	
SLOVENIA	GS			8.01			8.01			8.56

TABLE A4.2.8 | Time between the date of the answer to the VQ complaint and the elimination of the problem

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	208	84.1		161	85.7		192	88	14
HUNGARY	GS	3,577			2,388			3,375		

TABLE A4.2.9 | Time until the start of the restoration of supply following failure of fuse of DSO

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	12,778	99.9		12,962	99.8		12,366	99.9	1.4
GREAT BRITAIN	GS	60,836	0.45		44,315	0.59		0	0	
HUNGARY	GS	110,656	99.33		142,844	99.29		155,705	99.11	
ITALY	GS	113,404	98.8	1.67	117,306	99.1	1.63	109,549	99.1	1.56
PORTUGAL	GS	152,430	98.75		162,073	97.14		180,886	98.46	
SLOVENIA	GS			3.6			3.41			3.25
LATVIA	OAR			3.6			3.41			

TABLE A4.2.10 | Time for giving information in advance of a planned interruption

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
ESTONIA	OS							516,205	100	2
GREAT BRITAIN	GS	817,900	0.12		1,477,593	0.09		0	0	0
HUNGARY	GS	1,751,168	99.95		3,689,570	99.97		3,458,714	99.87	

TABLE A4.2.11 | Time until the restoration of supply in case of unplanned interruption

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS	60,769	98.30		62,531	99.70		60,405	99.8	2.4
ESTONIA	OS							1,235,061	98.7	
GREAT BRITAIN		18,896,635		63.90	18,894,992		60.49			
HUNGARY	GS	4,788,771	98.86		5,726,795	99.39		7,062,653	99.18	
PORTUGAL	OS	18,924,207	96.40		22,691,437	93.50		29,613,209	94.1	0.33
SLOVAK REPUBLIC	OAR				10,849,074	99.10		10,313,579	99.7	
SLOVENIA	OAR			5.82			6.09			6.52

TABLE A4.2.12 | Time for meter inspection in case of meter failure

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS							3,238	99.9	18
ESTONIA	OS							20,568	91.1	
HUNGARY	GS	3,406	90.87		4,105	92.18		4,485	95.79	
IRELAND	OM		72			71			72	
ITALY	GS	12,561	97.6	6.76	22,916	99.3	7.17	18,731	98.8	7.75
SLOVAK REPUBLIC	OAR				329	98.8		339	100	
SLOVENIA	OAR			5.28			4.99			4.88

TABLE A4.2.13 | Time from notice to pay until disconnection

Country	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
FRANCE								90.7	

TABLE A4.2.14 Time for restoration of power supply following disconnection due to non-payment

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
CZECH REPUBLIC	GS							62,944	100	1
HUNGARY	GS	25,929	90.87		36,538	97.29		77,978	99.13	
HUNGARY	GS	22,523	99.95		34,793	99.98		69,127	99.92	
IRELAND	OM		95			96			97	
ITALY	GS	1,176,879	99.5	0.2	1,236,841	98.5	0.21	1,290,738	99.6	0.12
PORTUGAL	GS				290,268	98.56		291,194	99.39	
SLOVAK REPUBLIC	OAR				31,942	98.9		29,655	99.8	
SLOVENIA	OAR			1			0.565			0.335

TABLE A4.2.15 Yearly number of meter readings by the designated company

Country	Type of requirement	Actual performance in 2008			Actual performance in 2009			Actual performance in 2010		
	OS, GS, OAR, OM	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time	Number of cases	Actual % of cases	Average performance time
ESTONIA	OM							527,989		
FRANCE	OM								97.8	
HUNGARY	OAR	5,425,590	NA	1.2	5,501,982	NA	1.21	5,337,580	NA	1.22
IRELAND	OM		96.5			92			95	
PORTUGAL	GS				28,017,355	99.993		28,887,039	99.996	

Annex on the 5th CEER Benchmarking Report - Quality of Electricity Supply in the Energy Community[22]

1. Introduction

1.1 The Energy Community

On 25 October 2005 the Treaty establishing the Energy Community (hereinafter: "the Treaty") has been signed by the European Community and the authorities of Albania, Bulgaria, Bosnia and Herzegovina, Croatia, the Former Yugoslav Republic of Macedonia (FYR of Macedonia), Romania, Serbia, Montenegro and the United Nations Interim Mission in Kosovo (UNMIK[23])[24]. Following signature and ratification of the Treaty Moldova and Ukraine moved from an observer status to the status of a Contracting Party (CP).

By signing the Treaty the signatory parties agreed to implement the acquis communautaire on electricity, gas, environment, competition and renewables[24] with a view to realizing the objectives of the Treaty and to create a regional gas and electricity market within South East Europe (SEE).

The **Energy Community Regulatory Board** (ECRB)[25] operates based on Article 58 of the Energy Community Treaty. As an institution of the Energy Community the ECRB advises the Energy Community Ministerial Council and Permanent High Level Group on details of statutory, technical and regulatory rules and should make recommendations in the case of cross-border disputes between regulators.

22. Approved by the ECRB in November 2011. All data, references and information referring to the date of approval.
23. Pursuant to United Nations Security Council Resolution 1244.
24. Following ratification, the Treaty entered into force on 1 July 2006. For details on the Treaty and the Energy Community see www.energy-community.org.
25. For details of the relevant acquis see: http://www.energy-community.org/portal/page/portal/ENC_HOME/ENERGY_COMMUNITY/Legal/Treaty
26. For details see www.ecrb.eu.

1.2 Scope

Quality of electricity supply is in the centre of the ECRB work since 2008[27]. Also the Council of European Energy Regulators (CEER)[28] puts a focus on quality of electricity supply already for a long time and prepares a Benchmarking Report on Quality of Electricity Supply in the EU Member States every third year, presenting an overview and analysis of practices related to quality of electricity supply[29].

Upon agreement of the CEER General Assembly, the present 5th Benchmarking Report on Quality of Electricity Supply also includes an annex analysing the status quo in the Energy Community Contracting Parties. This, more in detail, covers all three aspects of quality of electricity supply, namely:

1. Continuity of Supply (CoS);
2. Voltage Quality (VQ);
3. Commercial Quality (CQ).

Relevant data is presented for Albania, Bosnia and Herzegovina, Croatia, FYR of Macedonia, Moldova, Montenegro, Serbia, Ukraine and UNMIK. Where results for Bosnia and Herzegovina differ for its entities (the Federation of Bosnia and Herzegovina and Republika Srpska), they are displayed separately in this survey.

Within each chapter the findings and recommendations related to various issues of quality of supply are given. Where appropriate, examples from some CPs are emphasized in yellow boxes. The present survey also provides an assessment of areas where a move towards harmonisation could further improve quality of supply.

1.3 Methodology

The analysis for the Energy Community is based on a questionnaire used for CEER's analysis on EU level[30]. Therefore, the assessment for the Energy Community also bases on the definitions and theoretical background defined for the EU Member States.

1.4 Acknowledgements

The ECRB expresses its gratitude for the colleagues from the regulatory authorities (RAs), transmission system operators (TSOs) and distribution system operators (DSOs) from the Energy Community CPs for participating in the present analysis. In this context special thanks are also addressed to Mr David Batič, Mrs Jasmina Trhulj, Mr Lahorko Wagmann and Mr Zlatko Zmijarević for their effort in preparing this survey.

The ECRB also expresses its appreciation for the support received from the EU regulators at CEER level.

27. A first survey on quality of electricity supply in the Energy Community (EnC) was prepared in 2009 ("Report on the Quality of Electricity Service Standards and Incentives in Quality Regulation"; www.ecrb.eu – documents – publications – electricity (2009). Following two workshops in 2009 and 2010, the report "Assistance to regulators in introducing and improving service quality regulation in the Energy Community" was published in 2010 (www.ecrb.eu – documents – studies).
28. www.energy-regulators.eu.
29. The first report was issued in 2001, followed by the second, third and fourth editions in 2003, 2005 and 2008. All reports are available at www.energy-regulators.eu.
30. Reduced to the elements applied in the Energy Community jurisdictions.

2. Continuity of Supply

2.1 Introduction

This chapter provides an overview of the existing quality service regulation frameworks on continuity of supply (CoS) applied in the Energy Community CPs. Special focus is put on general experiences, experiences with the implementation processes and possible future improvements of the systems in place.

Analyses are made on the basis of data from CoS measurements and statistics as well as on the basis of information on audits on continuity data; regulation and standards on continuity of supply; incentive mechanisms for continuity of supply and effects of continuity of supply incentive regimes.

Although there is some evidence on improvements of the regulatory frameworks[31], **most of the observed jurisdictions are only in a very early stages of developing service quality regulation**. The main focus within this chapter is therefore put on the characteristics of continuity of supply monitoring schemes in distribution and transmission. The proper application of such schemes is the precondition for the future framework extensions.

Only for a minority of cases already applied minimal standards on continuity of supply and reward/ penalty schemes are presented as examples of existing regulatory practice in the area.

Review and analysis of collected data on continuity of supply show **differences in timing and scope of CoS monitoring development**. Consequently, the complete data set on different aspects of CoS monitoring and regulation expected from the questionnaire cannot be provided.

According to the questionnaire, continuity of supply is examined based on the following aspects:

- Continuity monitoring;
- Audits on continuity data;
- Regulation and standards on continuity of supply;
- Incentive mechanisms for continuity of supply;
- Effects of continuity of supply incentive regimes.

Information on the provided data on continuity of supply is provided in Table 1.

It can be concluded from Table 1 that **most of the assessed aspects are not applicable due to an**

TABLE 1 | Information on continuity of supply by CPs

CP	Continuity measurement	Audits on continuity data	Regulation and standards on continuity of supply	Incentive mechanisms for continuity of supply	Effects of continuity of supply incentive regimes	Data on Network and Continuity indicators
Albania	X (Partially)					
Bosnia and Herzegovina	X	X				X (Partially)
Croatia	X					X (Partially)
FYR of Macedonia	X					X (Partially)
Moldova	X	X	X	X		X (Partially)
Montenegro	X		X			
Serbia	X		X			X (Partially)
Ukraine	X	X				X (Partially)
UNMIK	X		X			X (Partially)

31. As regards minimal standards on continuity of supply as well as the implementation of incentive schemes in particular countries.

early stage of continuity of supply regulation in all CPs. The lack of data limits the possibility of benchmarking the actual levels and trends of continuity of supply in the investigated markets.

According to the current status of implementation, the following chapters mainly focus on an overview of the monitoring concepts and on the aspects and characteristics of the regulation frameworks applied (including standards on continuity of supply). The aim is to benchmark the implementation process of continuity of supply monitoring and regulation and to look deeper into their prerequisites, namely:

- the establishment of legal framework;
- usage of standards and guidelines of good practice;
- the implementation of the continuity of supply monitoring system;
- continuity standards and incentive schemes.

Such structured information might be of especial help for RAs that have plans to introduce quality regulation regime in depth in the future.

In the subsequent sections different terms for the network user are used, namely "customers", "consumers" and "(network) users". "Network user" (or simply "user", comprising both generators and other consumers), certainly, is the appropriate term. However, since there is no harmonisation on the terms used, different terms with the same meaning are used.

Also, different terminology is used when referring to the party responsible for continuity of supply. Although the EU Electricity Directives[32] (2nd and 3rd package) provide a definition of transmission and distribution system operators (or simply "system operators") the concept of system operation refers to dispatching of generators and it is different from network ownership and operation.

2.2 Continuity of Supply Monitoring

Monitoring of quality levels by the use of indicators and standards is the basis for regulating quality. In general, **the actual monitoring of continuity of supply can be performed on two different levels**, namely on the system level and on the consumer-specific level. The implementation of adequate monitoring systems is essential for setting standards as well as penalties and rewards related to both monitoring levels.

In the CPs, the monitoring of continuity of supply is performed in different ways - the differences comprise different types of interruptions, different sets of indicators, as well as different approaches on the level of detail of reporting. The following sections pinpoint the differences but also the concepts that are harmonised among the CPs. Harmonisation, where existing, has not been enforced by law but has been implemented through examples of good practice in the EU[33].

2.2.1 Types of Interruptions Monitored

All jurisdictions use some sort of monitoring of interruptions. The types of monitored interruptions are shown in Table 2.

The actual focus of the individual CPs is mainly on **long-term interruptions** (duration > 3 minutes). The qualitative information on long interruptions is essential for the calculation of continuity indicators that are widely used in regulation.

Three regulators claim to have access to the information regarding the number of **short-term interruptions**, namely Ukraine, FYR of Macedonia[34] and (partly) Bosnia and Herzegovina.

In this context it is important to explain the way how short-term interruptions are currently monitored, especially due to the fact that Supervisory control and data acquisition (SCADA) is not yet fully implemented in the networks of the CPs. Therefore, those CPs that reported monitoring of short-term interruptions were additionally asked to provide a brief information on the type of measurement method that is used[35].

In Bosnia and Herzegovina, most of the distribution facilities do not have equipment for remote supervision and control installed[36]. All (short and long) interruptions are recorded manually and stored locally in registers (registry books). Contingency statistics are recorded manually by the staff on duty. Registered data is consolidated in the main dispatching centres for the distribution network control. These data are subject to checks by the regulatory authority.

32. http://ec.europa.eu/energy/gas_electricity/legislation/third_legislative_package_en.htm
33. By adopting standards as EN 50160 and others.
34. However, details for FYR of Macedonia have not been reported.
35. I.e. manual recording, use of SCADA DMS, local substation logging, counter readings on reclosing devices or other methods.
36. Except for the facilities of one out of the five distribution companies in RS which have the SCADA system installed at MV.

Considering the general lack of SCADA, it can be concluded that **local substation logging and counter readings on reclosing relays are the most commonly used practices for recording the interruptions**.

Unplanned long interruptions are monitored in all investigated markets. However, not all CPs monitor this type of interruptions at all voltage levels.

Moreover, usually **there is also a distinct and separate data collection for planned and unplanned interruptions**. An "on time" announcement of the planned action reduces the effect of the interruption on the consumer.

Only Moldova has established rules on **automatic logging of interruptions**. Bosnia and Herzegovina and FYR of Macedonia have also accomplished to set some rules with limited scope[37]. The other investigated jurisdictions either have not set any rules yet or are only in a planning phase for establishing the rules and implement the SCADA system.

Nearly half of the CPs established some sort of **standardised way for recording and reporting** by means of dedicated application software or by use of harmonised forms for data collection. This is usually a result of regulations imposing obligations on companies to implement reporting without taking into consideration technical preconditions for interruption monitoring and time for such implementation. EU experiences showed that this is not the best approach and such practice **should be gradually replaced by the automated logging** of interruptions by SCADA and associate software solutions[38].

The definitions regarding the duration of long, short, and transient interruptions in different CPs are shown in Table 3.

The Albanian definition significantly **differs** from the other CPs as well as from standard definitions[39] which classify unplanned interruption[40] as:

- long interruption (>3 min);
- short interruption (≤ 3 min).

The deviation in Ukraine, where the interruption lasting exactly 3 minutes is classified as long-term interruption, is minor. The same can be concluded for UNMIK, where the same type of interruptions (duration = 3 min) is excluded from monitoring.

Some minor differences of definitions are also identified related to the duration of short interruptions, especially concerning the setting the lower limits[41].

Albania, again, is the only CP that defines **a category of transient interruptions**; the transient interruptions in Albania would classify as short interruptions in other countries.

2.2.2 Planned and Unplanned Interruptions

An overview on the definitions of unplanned[42] and planned[43] interruptions, as well as the rule on advance notice regarding the planned interruptions is provided in Table 4. **The majority of investigated markets (8 out of 9) use definitions for both planned and unplanned interruptions** referring to the availability of advance notices to customers. Both types of interruptions are monitored accordingly. There is no explicit definition of unplanned interruption in Croatia.

Most CPs use similar definitions for planned interruptions. However, they do not refer to EN 50160 or any other standards, international guidelines or norms. Advanced notification is necessary for an interruption to be classified as a planned interruption. More detailed descriptions of definitions, comprising also some information on exemptions, were provided by Ukraine, Bosnia and Herzegovina and Croatia.

All CPs apply rules on notice to customers affected, whereas the requirements for advance notice vary between 24 hours up to 10 days.

37. SCADA installed at certain voltage level or proprietary solutions by DSOs.
38. DMS, GIS and etc.
39. EN 50160.
40. Using the term "accidental supply" interruption.
41. Some definitions do not set lower bounds, some set the limit at 1.0 second or 1.5 seconds.
42. An unplanned interruption is defined in EN 50160 as an interruption caused by permanent or transient faults, mostly related to the external events, equipment failures or interference.
43. A planned interruption is defined in EN 50160 as an interruption for which customers are informed in advance to allow the execution of scheduled works on the distribution system.

TABLE 2 | Types of interruptions monitored

CP	Transient	Short	Long	Unplanned	Planned	Rules for automatic logging of interruptions (i.e. SCADA)	Standarnised system for recording and reporting of interruptions
Albania			X	X	X	No	No
Bosnia and Herzegovina		X, partly (E RS only)	X	X	X	Partly. Some DSO use proprietary software for processing of interruptions, some use SCADA system at MV.	Yes, there is a uniform form for keeping records on interruptions in electricity supply and reporting forms prescribed by the RA.
Croatia			X	X	X	No (It is planned to connect SCADA to the current application for handling information on long interruptions based on manual entry of data only.)	DISPO[44] is a system used by the DSO to collect data on long interruptions. Data is manually entered for the whole CP (1 DSO) divided in organisational units.
FYR of Macedonia		X	X	X	X	SCADA comprising 110 kV substations that have possibility for remote records of interruptions.	No
Moldova			X	X	X	Yes (Rules for recording of interruptions, approved by RA). A part of interruptions on MV networks are logged automatically, by SCADA, another part – manually. Interruptions at LV level are recorded only manually.	No
Montenegro			X	X	X	No	Yes, but for long interruptions only
Serbia			X	X	X	No	Standardised form for recording and reporting of long interruptions is prescribed by the Information Rules issued by the RA.
Ukraine		X	X	X	X	No	Yes, for DSO only (approved by the RA).
UNMIK			X	X	X	No (TSO is working towards accomplishment of the SCADA system.)	Not applicable

TABLE 3 | Definitions of long, short and transient interruptions

CP	Transient	Short	Long
Albania	< 3 min	< 15 min	> 15 min
Bosnia and Herzegovina	Not defined	1 s < T ≤ 3min	> 3 min
Croatia	Not defined	1.5 s < T ≤ 3 min	> 3 min
FYR of Macedonia	Not defined	1.5 s < T ≤ 3 min	> 3 min
Moldova	Not defined	≤ 3 min	> 3 min
Montenegro	Not defined	≤ 3 min	> 3 min
Serbia	Not defined	Not defined	> 3 min
Ukraine	Not used	< 3 min	≥ 3 min
UNMIK	Not defined	< 3 min	> 3 min

44. DISPO is the name of the computer application. It comes from the two Croatian words **DIS**tribucijska **PO**uzdanost (Distribution Reliability).

TABLE 4 | Definitions of planned and unplanned interruptions

CP	Planned	Unplanned	Rules issued about notice to customers affected
Albania	Customers are noticed in advance.	All breakdowns not noticed in advance.	Rules and procedures for giving notice defined by DSO are applied (72 hours in advance).
Bosnia and Herzegovina	Planned interruptions are those announced ones for the purposes of doing planned activities of regular and extraordinary maintenance, inspection and overhaul, connections of new customers, testing and control of measuring and protection devices and enlargement of the network.	Non-planned interruptions are those non-announced. If the planned interruption lasts longer than it has been announced, the time period exceeding the planned is included in the non-planned interruptions for which the operator is responsible.	Distributor is obliged to inform the end users on the term and expected time of duration of the planned interruption, no later than 24 hours (RS)/48 hours (Federation BiH) before the planned interruption as follows: • for end users at medium voltage - directly by phone along with the written notice on information details by fax or email; and • for end users at low voltage - via mass media, in a clear and appropriate way.
Croatia	No specific definition is given, although the DSO is allowed to interrupt the supply for the following reasons: • equipment monitoring and measurements; • scheduled and forced maintenance; • reconstructions; and • connection of new customers.	No specific definitions	Consumers on HV, MV and LV, category "entrepreneurship above 30 kW" must be informed directly (by phone, fax or mail) at least 48 hours in advance. Other customers on LV must be informed via mass media (radio, TV...) at least 24 hours in advance.
FYR of Macedonia	An interruption notified in advance to all affected customers with adequate notice.	An interruption not notified in advance to all affected customers or notified with inadequate notice.	Timely in written form in case of individual customers affected, 24 hours in advance in case of a group of customers affected.
Moldova	An interruption notified in advance to all affected customers with adequate notice.	An interruption non notified in advance to all affected customers or notified with inadequate notice.	A planned interruption must be notified to all affected customers. For customers with contracted power less than 100 kW the notification need be done 3 days before interruption, by phone, TV, mass-media etc. For bigger customers (more than 100 kW), the notification must be done in written, 7 days before the planned interruptions.
Montenegro	An interruption notified in advance to all affected customers with adequate notice.	An interruption non notified in advance to all affected customers (an interruption not notified on time to all affected customers.)	The minimum time-lag requested is at least 24 hours, notice by public media or in another adequate way.
Serbia	An interruption notified in advance to all affected customers with adequate notice.	An interruption non notified in advance to all affected customers.	The minimum time-lag requested is at least 24 hours, noticed by public media or in other adequate way.

CP	Planned	Unplanned	Rules issued about notice to customers affected
Ukraine	De-energization of a part of the network and equipment, made by the DSO to undertake routine repair or maintenance of electrical networks. Exemptions are also defined.	Temporary suspension of power supply to consumers as a result of de-energization of a part of the network due to the fault of other licensees (UTILITIES), consumers, force majeure event, fault of others, technical failures in the electrical network of the DSO.	10 days for legal entities with repeated notice 1 day and 10 days for households.
UNMIK	An interruption notified in advance to all affected customers with adequate notice.	An interruption non notified in advance to all affected customers or notified with inadequate notice.	Where the DSO carries out planned service interruptions on the distribution system it shall use its best endeavors to ensure that it provides a minimum of 24 hours notice to at least 90% of the affected customers. For the purposes of this standard, the notice given to affected customers shall be in the form of announcements through local TV and radio for interruptions that occurs in local areas (limited) and where the proposed interruption is widespread, through TV and suitable high-circulation daily newspaper.

2.2.3 Voltage Levels Monitored

The incidents at different voltage levels are monitored in different CPs as shown in Table 5.

Incidents on Medium Voltage (MV) and High Voltage (HV) level are monitored in all CPs. Surprisingly most of the investigated markets report to monitor interruptions on Low Voltage (LV) level (except for Albania). Reliable recording of interruptions on LV level (interruption register) requires big investments in equipment for data protection and remote supervision as well as control or call centre functions, and, therefore, it is not yet widely implemented even in the EU Member States.

Efficient monitoring of interruptions for particular voltage levels covers recording the interruptions caused by incidents on own voltage level and by incidents on all higher voltage levels that affects the observed one[45]. However, interruptions that are caused on LV remain unrecorded in case there is no manual, semi-automated (i.e. using call centre services) or automated process of monitoring implemented at LV network (i.e. SCADA). The interruptions caused in LV that do not affect the protection system under supervision of SCADA installed on MV (or LV) or that are not reported by the affected customers via call centres, are not recorded in MV statistics and consequently the CoS indicators.

Incidents in transmission networks are monitored in 4 out of the 9 CPs. Only Ukraine, monitoring on LV level already since 2008, is in on good way to achieving comprehensive monitoring on all voltage levels.

Ukraine - Monitoring of interruptions on LV

In Ukraine, the DSO is obliged to provide information on LV interruptions to the RA. Usually DSOs do not have SCADA, remote control or signaling systems on LV level. Interruptions are recorded manually by the staff on duty in the operations journal (paper event log) on the basis of first call from the customers to the staff or to the Call Centre as well as remote control and signaling, if available.

Data is transferred to an electronic register and sent to the RA.

45. For example, a fault at MV will result in interruption for an LV customer: such interruptions may be recorded (registered) also for LV level.

TABLE 5 | Voltage levels for which monitoring of continuity takes place

CP	LV	MV	HV	EHV
Albania		X	X	
Bosnia and Herzegovina	See note	X	X	X
Croatia	See note	X	X	
FYR of Macedonia	See note	X	X	
Moldova	See note	X	X (>10 kV)	
Montenegro	See note	X	X	
Serbia		X	X	X
Ukraine	X[46]	X	X	X
UNMIK	See note	X	X	X

Note:
The table represents the voltage level for which incidents are recorded. The incident is typically recorded by an opening of a circuit breaker or another interrupting device. The customers at that voltage level and at any lower voltage levels have their interruptions counted in that way. Although also monitoring on LV level was reported by CPs. In practice LV recording is partially implemented only in Ukraine. In many CPs, the network operators usually provide the number of affected customers on LV due to the interruption at certain (higher) voltage level (i.e. MV) and this number is considered when calculating continuity indicators. However, this is not sufficient to be considered as monitoring of interruptions at certain voltage level.

2.2.4 Classification of the Cause of Interruption

An overview on the classification of interruption causes is given in Table 6. Such information is very important for both the system operator and the regulator. **Most CPs collect** related information.

From the CPs' answers it can be concluded that there is **no harmonisation as regards the classification of reasons for interruption.** Almost all CPs know sub-categories of reasons. 7 CPs[47] use the categories "third party" or "force majeure".

It is interesting that Ukraine also uses the category "planned interruption without notice" – such classification indicates quite sophisticated integration of different databases, and implementation of interacting e-business processes supporting such classification.

2.2.5 Exceptional Events

Exceptional weather conditions and other exceptional circumstances can significantly affect the continuity of supply. Interruptions, due to exceptional events, are usually very long and/or affect a substantial number of customers, even if quite rare. The concept of exceptional events reflects the unique characteristics of each CP's electricity sector and the impact of severe weather conditions in each CP.

This section contains information on existing concepts on exceptional events[48] in the CPs. In Table 7, exceptional events, their definitions and their influence on interruption statistics are presented.

Albania, Montenegro and Serbia do not consider the concept of exceptional events or other similar concepts related to situations which are subject to the specific treatment in their quality of supply regulations. In Serbia, the information code regarding the classification of interruptions comprises the definition of force majeure.

In the other 6 jurisdictions, the concepts of exceptional events are defined as described in Table 7 and can be generally grouped as follows:

- Extraordinary situations with significant impact on the continuity of supply (Bosnia and Herzegovina, Moldova and Ukraine); and
- Force majeure (Croatia, Moldova, FYR of Macedonia and UNMIK[49]).

These situations can be classified based on their reason or on their impact on network performance.

The answers received also indicate that Croatia and Moldova use the designation of force majeure, and employ it not only for service quality regulation but also, in a more general way, in civil law.

46. Established since 2008; Usage of data from Call Centre IS + manual processing (see also the "Ukraine's box").
47. I.e. all investigated markets except for Montenegro and UNMIK.
48. The term "exceptional events" is used in accordance with the terminology used by CEER.
49. Assumption since information has not been provided.

TABLE 6 | Cause categories used when recording interruptions

CP	Categories used when recording interruptions	Recording scope (All/ Only of specified cause)	Separately recording according to interruption's cause	Classification of causes adopted
Albania	1) Planned interruptions 2) Force majeure 3) Third Party 4) DSO Responsibility	All	Yes	The classification, which relates to: transformers, bus bars, isolators, cable, wires, etc.
Bosnia and Herzegovina	Interruptions caused by force majeure, third party responsibility and responsibility of distributor.	All	Yes	Force majeure, third party responsibility and responsibility of distributor.
Croatia	Ca. 30 categories like bad maintenance, manipulation errors, technical causes, third party, force majeure, etc.	All	Yes	Ca. 30 categories like bad maintenance, manipulation errors, technical causes, third party, force majeure, etc.
FYR of Macedonia	HV and MV: unplanned, planned, interruptions due to force majeure, interruptions due to weather conditions, damages caused by third persons, due to interruptions on the transmission grid.	All (HV, MV)	Yes	Planned, unplanned, interruptions due to force majeure, interruptions due to force weather conditions, damages caused by third persons, due to interruptions on the transmission grid.
Moldova	- Force majeure or special meteorological conditions, - Caused by consumers' installations, - Caused by third parties, - Other causes	All	Yes	1. Planned interruptions 2. Unplanned interruptions: 2.1 caused by special meteorological conditions or force majeure; 2.2 caused by incidents in consumer's installations; 2.3 caused by a third party; 2.4 other causes – failures in the distribution network, which the DSO is responsible for.
Montenegro	Planned works, damages in the system, damages with customers, meteorological conditions, unknown causes.	All	Yes	Planned works, damages in the system, damages with customers, meteorological conditions, unknown causes.
Serbia	Own network/other energy entity/third party/ animals/force majeure/unknown/other	All	Yes	Own network/other energy entity/third party/animals/force majeure/unknown/other
Ukraine	Planned interruption with notice; Planned interruption without notice; Unplanned (emergency) interruption through the fault of other licensees or consumers; force majeure; Unplanned (emergency) interruption through the fault of others; Unplanned (emergency) interruption due to the technical failures in the electrical network of the licensee.	All	Yes	
UNMIK	Planned and unplanned interruptions.	All	Yes	Interruptions that result from distribution system faults.

TABLE 7 | Definitions of exceptional events

CP	Designation	Concept	Exceptional events excluded from the interruption statistics
Albania	Not defined	Not applicable	No
Bosnia and Herzegovina	Force majeure	"Force majeure" - all events which cause interruption of supply, and are out of control of a distributor: natural disasters (earthquake, fire, flooding), extreme weather conditions (lightning, storm wind, excessive ice etc.), interruptions at the transmission voltage level, load shedding due to shortage of supply, under-frequency relief of load and orders of the respective authorities.	Normally not (but available also excluded).
Croatia	Force majeure	Energy law (Article 31.b.): the events of force majeure include any events or circumstances which even if foreseeable cannot be prevented and which cannot be influenced, diminished, removed or rendered inactive. These are, in particular: - natural disasters (earthquake, flood, lightning strike, storm, icing, etc.); - epidemics; - explosions, other than those caused by improper or careless handling, which are not foreseeable and are not due to wear and tear of materials or equipment; - war, riot or sabotage; and - decisions of the Government of the Republic of Croatia referred to in Article 23 of this Act, as well as any other events or circumstances recognized and designated as force majeure by special arbitration.	No
FYR of Macedonia	Force majeure	Force majeure is defined as all unpredictable natural events, disasters and circumstances determined by the law (defined in Rulebook on conditions for electricity supply).	No (data is available upon request).
Moldova	Special meteorological conditions + force majeure	Special meteorological conditions are situations, where: • wind speed exceeds 30 m/s; • frost thickness exceeds 20 mm; and • frost layers and wind exceeding 15 m/s. Also, the force majeure situations are defined by the law.	Yes
Montenegro	Not defined	Not applicable	No
Serbia	Force majeure[50]	Events, circumstances or occurrences beyond the control of the system operator, the appearance of which he could not foresee, avoid or eliminate, and in particular natural phenomena such as – floods, earthquakes, landslides and rock falls, as well as social phenomena – wars, terrorist acts and strikes, as well as measures and decisions of governmental bodies.	No
Ukraine	Force majeure	Yes. Interruption due to force majeure – interruption as a result of an irresistible emergency force which cannot be prevented by the use of highly skilled personnel and practices and can be caused by exceptional weather conditions and natural disasters (hurricanes, storm, flood, snow accumulation, ice, earthquake, fire, subsidence and landslide) and other contingencies. The event of force majeure must be documented.	No, but interruption due to exceptional events are not used for calculation of target indices.
UNMIK	Force majeure	Information not provided.	Yes

No statistical methods defining "major event days" or "exceptional condition periods"[51] exist. There is also no evidence on explicit regulations defining "exceptional events".

The information collected from the CPs shows a lack of harmonisation which is probably caused by different concepts of legislation on obligations and by inherent climate differences. Therefore,

50. Informational definition only.
51. IEEE Standard 1366-2003, Annex B.

stringent harmonisation might most probably not be feasible at all. The lack of harmonisation as regards exceptional events affects the comparison of interruption data between the observed countries significantly.

It is important to mention that Moldova and UNMIK exclude exceptional events from their statistics. In Bosnia and Herzegovina and FYR of Macedonia separate statistics (with/without exceptional events) are provided upon request.

2.3 Continuity of Supply Indicators

An overview on the definitions of different indices used for quantifying the number of interruptions is provided in CEER's "4th Benchmarking Report on Quality of Electricity Supply" (2008) [4].

The same definitions are used for the purpose of the present analysis for the Energy Community.

Continuity of supply indicators measure grid performance at delivery points. The meaning of these indicators depends on the set of interruptions considered in calculation and related interruption durations. If all interruptions are considered in the indicators calculation, they provide information on the continuity of supply as experienced by the customers. Such calculation is also important for evaluating the impact of the exceptional/force majeure events in terms of continuity of supply. For such analysis, all interruptions caused by exceptional events must be identified.

Usually, the indicators for long interruptions are split into two categories, namely unplanned and planned interruptions. Short interruptions are mostly caused by unexpected events, therefore a separation in planned and unplanned cases is not used.

There are no significant CP-specific differences between typically used continuity indicators. A range of indicators is used, depending on their purpose and, of course, availability and comprehensiveness of the interruption statistics.

Regarding the measurement of long interruptions (> 3 minutes), the most common indicators for measuring continuity of supply are System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) for distribution networks and Energy Not Supplied (ENS) and Average Interruption Time (AIT) for transmission networks. Momentary average interruption frequency index (MAIFI) values are used for short interruptions.

2.3.1 Level of Details of the Calculated Indicator

Continuity of supply indicators can be calculated for one jurisdiction or a region as a whole, for each system operator, for a certain city, for each feeder or even for each individual customer. Calculation of indicators for a different observation scope is an essential tool in the process of benchmarking for regulators and systems operators. Regulators use related data for benchmarking DSOs, for setting the appropriate continuity standards according to regional or network characteristics, etc. DSOs can use such data to make investment or maintenance decisions. The practice on calculation of system indicators varies strongly between different countries, as shown in Table 8.

All CPs publish indicators calculated for the whole jurisdiction. In only few of the investigated markets, the indicators are calculated per system operator and/or per region/city.

Further distinctions can be made based on the voltage level on which the incident takes place or on the cause of the incident. **A distinction based on voltage level is made by all CPs. Information on the cause of the incident is also provided by all CPs. However, the classifications used for the voltage levels and causes significantly differ between the investigated markets**, reasoned by different level of data availability and non-harmonised types of causes among CPs. Four CPs provided separate indicators for rural and urban areas; one distinguishes between underground and overhead ("aerial") networks. Also here, different CPs use different classifications. Bosnia and Herzegovina reported that indicators are calculated also according to the grounding of MV networks.

For the three of the analysed markets that provided disaggregated data according to the network type, the classification concepts are as follows:

- *Bosnia and Herzegovina*: in Republika Srpska the classification of distribution areas is done without a formal definition by DSO as follows: city areas, outskirts, village areas; the indices are calculated only in a aggregated form in Federation BiH;

- *Croatia*: SAIDI and SAIFI are reported on CP level and per different organisational units. In the application software "DISPO". The indicators are calculated separately per three different unit categories (A,B,C) based on the number of customers in each unit[52] as follows: A (less than 15000 customers), B (between 15000-30000 customers), C (more than 30000 customers). The calculation of indicators is also possible on the level of system operator, region, city (district), sub-station and the level of MV feeder; and
- *Ukraine*: the Supreme Council Presidium Decree № 1654 X "Settlement of administrative-territorial structure" defines separation of urban settlements from rural settlements.

TABLE 8 | Level of detail in interruption recording

CP	CP level	System Operators	Region	City/District	Sub-station	Feeder	Customer	Voltage level	Causes	Urban/Rural	Cable/Overhead	Other
Albania	X							X	X	X	X	
Bosnia and Herzegovina	X	X	X (Partly)					X	X	X		X (grounding of MV network)
Croatia	X	X	X	X	X	X		X	X	X		
FYR of Macedonia	X							X	X			
Moldova	X							X	X			
Montenegro	X							X	X			
Serbia	X							X	X			
Ukraine	X			X				X	X	X		
UNMIK	X							X	X (planned/ unplanned only)			

2.3.2 Indices for Long and Short Interruptions

An overview of the different indices used for quantifying long interruptions as well as the weighting method used when calculating indices is provided in Table 9.

SAIDI and SAIFI are the most commonly used indices for distribution networks. Moldova and Serbia additionally calculate the index Customer Average Interruption Duration Index (CAIDI) which is a derivate of SAIDI in SAIFI.

The method of weighting has an impact on the results by introducing different basic indicator approaches. **All CPS that calculate the indices use the same weighting method**, namely based on the number of customers. Each customer is therefore treated equally, independent of its size and load profile. This is an important finding that has positive impact on benchmarking.

ENS and AIT are the most commonly-used indices for continuity of supply in transmission networks.

52. The number implicitly reflects density.

TABLE 9 | Long interruption – indices for quantifying

CP	Index	Weighting (N/A for ENS)
Albania	Raw data on interruption properties and location of interruption only.	The number of customers (identified manually).
Bosnia and Herzegovina	SAIDI & SAIFI ENS (transmission)	The number of customers (manually, using the connectivity models or estimated).
Croatia	SAIDI & SAIFI	The number of customers (enumerated manually or estimated).
FYR of Macedonia	None	Not applicable (no rules, SCADA is used on HV level).
Moldova	SAIDI, SAIFI, CAIDI, ENS, AIT (transmission - data not yet available)	The number of customers (automatically through the connectivity model).
Montenegro	None[53]	Not applicable
Serbia	Distribution -SAIDI, SAIFI, CAIDI; AIT, ENS (transmission);	Distribution indicators (SAIDI, SAIFI) - number of customers; transmission indicators (AIT)- average power supplied (weighting is done manually according to the RA rules).
Ukraine	SAIDI, SAIFI, ENS (transmission - data not yet available)	The number of customers (according to the average number of customers per MV/ LV transformer and average number of customers per LV feeder).
UNMIK	SAIDI, SAIFI, ENS (transmission)	The number of customers (manually by DSO).

The number of **short interruptions** per year (MAIFI) is used as indicator in Bosnia and Herzegovina (but only for the distribution network of the power utility "Elektroprivreda Republike Srpske") and in Ukraine, based on SCADA, where available. **None of the CPs gathers data on transient interruptions**.

Bosnia and Herzegovina – recording of short interruptions

In Bosnia and Herzegovina, the majority of DSOs use equipment for remote supervision and control installed (except for the facilities of one of the five distribution companies in Republika Srpska that uses SCADA at MV level). Short interruptions are recorded manually and stored locally in registers (records on outages). Short interruptions are recorded manually by the staff on duty. Registered data is consolidated in the main dispatching centres for the distribution network control. This data is also subject to checks by the RA staff during monitoring activities.

Ukraine – recording of short interruptions

Only few DSOs have SCADA installed. Almost all of them have a remote control or signaling system on MV and HV levels. Short interruptions are recorded manually by the staff on duty in the operator's journal (paper event log) on the basis of remote control and signaling: SCADA (if available); and call from the staff in transformer substation.

Data is transferred to the electronic register and sent to the RA.

53. TSO and DSO are not obliged to provide data on interruptions (AIT, ENS, SAIDI, SAIFI, CAIDI ...). RA plans to introduce such obligations in the future.

2.4 Analysis of Data on Continuity of Supply

This section provides an overview of the CPs´ networks and compares the values of the most important indicators over a number of years. Even though the calculation methods slightly differ between the analysed markets, the results are shown in the same diagrams. When interpreting the results, the differences in calculation and scope of monitoring (voltage levels) should be considered.

Albania and Montenegro did not provide answers and are therefore not reflected in the assessment. FYR of Macedonia provided some data on the number and duration for long and short interruptions for different voltage levels, however data on indices is not available.

The other CPs[54] provided very different sets of data on indicators. In terms of the diversity of indicators used, Croatia, Bosnia and Herzegovina and Ukraine provided the most comprehensive responses.

However, some of the indices provided by Bosnia and Herzegovina did not cover the whole jurisdiction[55]. The indices calculated on CP level have been provided to the extent possible, aggregating the contribution from Federation BiH (F-BiH) and Republika Srpska[56].

Some CPs provided data both with and without exceptional events[57], whereas others[58] provided one dataset or the other, mainly due to problems related to the identification of exceptional events. **The majority of analysed markets (7 out of 9) do not exclude exceptional events from their statistics on continuity of supply**. Only in Croatia all reported indices explicitly comprise the interruptions due to exceptional events[59]. For ensuring comparability, data on indices that exclude exceptional events provided by some CPs is therefore excluded from the assessment.

For the purpose of this benchmarking it is crucial to exclude the influence of CP specific factors from indices, caused by non-harmonised proprietary rules applied for interruption monitoring. The typical example is the influence of exceptional events. As it was not possible to neutralize the consequences of these differences between the CPs from the reported CoS index values by excluding the impact of exceptional events[60], it is also **very difficult to assess how exceptional events influence the interruption statistics of each CP. Accordingly, any conclusion concerning the level of continuity of supply that exclusive relates to the responsibility of the performance of system operators is not feasible.**

Due to the lack of availability of required data and problems of comparability, the benchmarking analysis is focused on the indices that have been provided by at least four CPs[61]:

- representing the value aggregated on CP level;
- comprising interruptions at all voltage levels monitored; and
- including the interruptions caused by exceptional events.

Furthermore, some additional analysis on the impact of planned interruptions is shown in the total statistics.

The reported set of indices per CP and the indices that are used in comparison (bold "X") are shown in Table 10.

54. Covering HV, MV and aggregation (HV+MV) for both unplanned and planned interruptions.
55. There is no data available for a separate administrative unit in Brčko District.
56. Usually, data is available, split among the power utilities as follows: [1] Power Utility "Elektroprivreda Republike Srpske" (E RS); data refers to Republika Srpska; [2] Power Utility "Elektorprivreda BiH" and the Power Utility "Elektroprivreda HZHB"; data refers to Federation BiH (FBiH).
57. Bosnia and Herzegovina and Ukraine.
58. Croatia, Moldova, Serbia and UNMIK.
59. Regardless of the classification of the indices in the questionnaire.
60. Exceptional events are mostly not excluded from the interruption statistics.
61. The same type of index has been benchmarked by CEER.

TABLE 10 | The indices provided

Continuity indicator	Interruptions considered	Scope	Bosnia and Herzegovina	Croatia[62]	Moldova[63]	Serbia	Ukraine	UNMIK
UNPLANNED, SAIDI	**w/o exc. events (all networks)**	**Whole CP**	**X**	**X**	**X**		**X**	**X**
UNPLANNED, SAIFI	**w/o exc. events (all networks)**	**Whole CP**	**X**	**X**	**X**		**X**	**X**
UNPLANNED, SAIDI	**All interruptions (all networks)**	**Whole CP**	**X**	**X**		**X**	**X**	
UNPLANNED, SAIFI	**All interruptions (all networks)**	**Whole CP**	**X**	**X**		**X**	**X**	
PLANNED, SAIDI	**All interruptions (all networks)**	**Whole CP**	**X**	**X**		**X**	**X**	
PLANNED, SAIFI	**All interruptions (all networks)**	**Whole CP**	**X**	**X**		**X**	**X**	
UNPLANNED, MAIFI	All interruptions (all networks)	Whole CP	X				X	
AIT (transmission)	w/o exc. events (only interruptions on T network)	Whole CP, transmission system		X		X		X
ENS (transmission)	**w/o exc. events (only interruptions on T network)**	**Whole CP, transmission system**	**X**	**X**		**X**		**X**
UNPLANNED, MAIFI	w/o exc. events (all networks),	Whole CP					X	
Unplanned AIT (transmission)	w/o exc. events (only interruptions on T network)	Whole CP, transmission system				X		
Planned AIT (transmission)	w/o exc. events (only interruptions on T network)	Whole CP, transmission system				X		
Unplanned ENS (transmission)	w/o exc. events (only interruptions on T network)	Whole CP, transmission system	X			X		
Planned ENS (transmission)	w/o exc. events (only interruptions on T network)	Whole CP, transmission system	X			X		
UNPLANNED, SAIDI	w/o exc. events (only interruptions on EHV networks)	Whole CP, EHV	X					
UNPLANNED, SAIDI	w/o exc. events (only interruptions on HV networks)	Whole CP, HV		X			X	
UNPLANNED, SAIDI	**w/o exc. events (only interruptions on MV networks)**	**Whole CP, MV**	**X**	**X**	**X**		**X**	
UNPLANNED, SAIDI	w/o exc. events (only interruptions on LV networks)	Whole CP, LV	X	X			X	
UNPLANNED, SAIFI	w/o exc. events (only interruptions on HV networks)	Whole CP, HV		X			X	
UNPLANNED, SAIFI	**w/o exc. events (only interruptions on MV networks)**	**Whole CP, MV**	**X**	**X**	**X**		**X**	
UNPLANNED, SAIFI	w/o exc. events (only interruptions on LV networks)	Whole CP, LV	X	X			X	
UNPLANNED, MAIFI	w/o exc. events (only interruptions on HV networks)	Whole CP, HV					X	
UNPLANNED, MAIFI	w/o exc. events (only interruptions on MV networks)	Whole CP, MV					X	

Legend: All networks: EHV, HV, MV and LV; w/o exc. Events: interruptions not attributable to exceptional events.

Only three CPs, namely the Croatia, Bosnia and Herzegovina and Ukraine provided indices classified by territorial density. The reported set of indices per CP is shown in the table below.

62. Force Majeure not excluded.
63. Only MV network covered.

TABLE 11 | The indices by territorial density

Continuity Indicator	Interruptions Considered	Territory	Bosnia and Herzegovina	Croatia[64]	Moldova	Serbia	Ukraine	UNMIK
UNPLANNED, SAIDI	w/o exc. events (all networks)	Only urban areas	X	X			X	
UNPLANNED, SAIFI	w/o exc. events (all networks)	Only urban areas	X	X			X	
UNPLANNED, MAIFI	w/o exc. events (all networks)	Only urban areas					X	
UNPLANNED, SAIDI	w/o exc. events (all networks)	Only suburban areas	X	X				
UNPLANNED, SAIFI	w/o exc. events (all networks)	Only suburban areas	X	X				
UNPLANNED, SAIDI	w/o exc. events (all networks)	Only rural areas	X	X			X	
UNPLANNED, SAIFI	w/o exc. events (all networks)	Only rural areas	X	X			X	
UNPLANNED, MAIFI	w/o exc. events (all networks)	Only rural areas					X	

Limitation #1: *The analyses performed were based on the data provided by the CPs "as-is". Auditing procedures may not have been carried out in CPs or may have been performed in a very limited scope. In future benchmarking reports data should be supplemented with remarks on validity, consistency and acquisition in order to provide accurate analyses.*

2.4.1 Interruptions Originated on Different Voltage Levels

Considering all facts and issues discussed in the previous chapters, concentrated by the fact that incidents on MV have the largest impact on the CP indices[65], the available aggregated data of all those comparable indices that comprises interruptions occurring on MV was benchmarked among the CPs.

Due to the identified problems concerning the calculation of indices SAIDI and SAIFI on transmission level, the following analysis only covers the incidents that occurred on HV, MV and LV voltage levels. The contribution of Extra High Voltage (EHV) is therefore not considered in the analysis.

Data clearly indicates that in average 85% of both SAIDI and SAIFI for LV users are caused by incidents on MV networks, as illustrated in the tables below.

TABLE 12 | Unplanned SAIDI (all events; HV, MV, LV) - distribution of incidents according to their voltage level [%]

CP	2006	2007	2008	2009	2010	Avg
Bosnia and Herzegovina (E RS only) - LV			7,61	12,43	5,58	8,54
Bosnia and Herzegovina (E RS only) - MV			89,40	88,88	90,71	89,66
Bosnia and Herzegovina (E RS only) - HV			2,99	Note[66]	3,71	1,80
Croatia - LV	4,70	16,64	7,73	7,58	9,66	9,26
Croatia - MV	92,18	76,19	87,61	86,53	85,22	85,55
Croatia - HV	3,12	7,16	4,66	5,90	5,12	5,19
Ukraine - LV				15,30	13,95	14,62
Ukraine - MV				84,35	85,17	84,76
Ukraine - HV				0,35	0,88	0,61

64. Force majeure is not excluded.
65. Adding up to at least 70%.
66. Calculation returned irrational result.

TABLE 13 | Unplanned SAIFI (all events; HV, MV, LV) - distribution of incidents according to their voltage level [%]

CP	2006	2007	2008	2009	2010	Avg
Bosnia and Herzegovina (E RS only) - LV			3,26	3,57	1,79	2,88
Bosnia and Herzegovina (E RS only) - MV			93,30	88,07	96,38	92,58
Bosnia and Herzegovina (E RS only) - HV			3,44	8,36	1,83	4,54
Croatia - LV	5,46	7,04	6,45	5,36	6,50	6,16
Croatia - MV	75,43	76,30	72,35	79,02	80,00	76,62
Croatia - HV	19,11	16,67	21,20	15,63	13,50	17,22
Ukraine - LV				14,19	13,29	13,74
Ukraine - MV				84,78	84,89	84,83
Ukraine - HV				1,04	1,81	1,43

In average, about 85% of SAIDI and SAIFI are reasoned by incidents on MV. It is important to point out that incidents at EHV were not considered in this analysis[67].

Limitation #2: *The crucial assumption for the following analysis is that comparison of continuity indices comprising interruptions at different sets of voltage levels, but always including MV, will not be subject to unpredictable error. Based on the EU datasets, it might be expected that the maximum error in interruption indices reaching a 30% underestimation, when not including interruptions on LV, HV and EHV levels, but most probably less, if assumed that interruptions on LV are mostly not adequately recorded. Only Moldova reported the continuity indices SAIDI and SAIFI for the MV level. The other CPs reported the same indices comprising interruptions recorded on various voltage levels. The continuity level of Moldova is therefore considered worse than identified in the comparison.*

2.4.2 Evaluation of the Impact of Exceptional Events

A difference between the same type of indices including exceptional events and those excluding exceptional events was identified in several CPs. This may be an indication of the presence of exceptional events in the continuity indices according to the CP´s rules on classification of interruption causes.

The following analysis provides a comparison of the indices including interruptions that were recorded in all networks with exceptional events included and those reported without exceptional events (SAIDI and SAIFI due to incidents at MV only). The disaggregated data on continuity indices without exceptional events that include the interruptions recorded on HV, MV and – sometimes[68] - also LV voltage levels has been aggregated and compared to the aggregated indices comprising the exceptional events[69].

The contribution of interruptions recorded on MV (supposedly without exceptional events) in the aggregated indices[70] is shown in the tables below (Table 14, Table 15). By analyzing the extent of the contribution on MV we can assume the contribution of interruptions recorded at EHV (also LV and/or HV, depending on each CP) and those reasoned by the exceptional events in the indices.

67. Experience on EU level shows that this proportion is very small especially if observed in the networks with a relative small ratio of undergrounding at MV and LV.
68. Croatia, Ukraine.
69. According to the definition, the latter should also include interruptions recorded at EHV.
70. Covering interruptions in all networks and supposedly comprising exceptional events.

TABLE 14 | Unplanned SAIDI (all events) - Contribution of MV to the aggregated value [%]

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - MV				82,36	53,75
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				17,64	46,25
Croatia - MV	65,49	48,43	58,32	62,05	50,43
Croatia - Other (LV, HV, EHV, exceptional events)	34,51	51,57	41,68	37,95	49,57
Ukraine - MV				55,75	60,20
Ukraine - Other (LV, HV, EHV, exceptional events)				44,25	39,80

TABLE 15 | Unplanned SAIFI (all events) - Contribution of MV to the aggregated value [%]

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - MV				77,40	70,61
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				22,60	29,39
Croatia - MV	55,67	55,23	51,99	59,20	57,35
Croatia - Other (LV, HV, EHV, exceptional events)	44,33	44,77	48,01	40,80	42,65
Ukraine - MV				63,97	65,81
Ukraine - Other (LV, HV, EHV, exceptional events)				36,03	34,19

In Croatia and Ukraine (and, in 2010, also in Bosnia and Herzegovina), the contribution of interruptions on MV on SAIDI is below the European average[71]. The same is observed for SAIFI[72], especially in Croatia and Ukraine. Contribution of SAIFI on MV in Bosnia and Herzegovina is close to the European average.

Due to the identified problems related to the robustness of the provided data, the impact of different sets of voltage levels considered in the calculation of indices[73] is difficult to evaluate. If the presence of exceptional events is neglected, the difference between the aggregated value of indices and the values containing the interruptions on MV only represents the contribution of other voltage levels to the aggregated value of indices, including EHV[74]. Possible reasons for this are:

- A lack of recording interruptions on MV (mostly manual processing): the proportion of interruptions recorded at MV is lower than expected;
- Differences between CPs as regards rules and practice for the recording of interruptions and, even more, the calculation of indices SAIDI and SAIFI on EHV level (transmission) due to different weighting calculation methods and the use of estimation methods; and
- Differences between CPs as regards rules and interpretation of exceptional events.

Limitation #3: *If we assume that exceptional events are present and estimate the contribution of LV, HV and EHV adding up to 30%, the exceptional events contribute to the aggregated values of indices with a maximum of 15%. As expected, their contribution on SAIDI is bigger than on SAIFI. At the same time, it is obvious (see Table 14, Table 15) that the contribution is not volatile, especially observing the trends of Croatia and Ukraine. The explanation for this could be in the consideration of the weather circumstances that occur once a year or more often as exceptional events (i.e. lightning).*

Limitation #4: *Only Moldova reported continuity indices SAIDI and SAIFI that do not cover exceptional events. The other CPs reported the same indices comprising also interruptions supposedly attributed to exceptional events. The continuity level of Moldova is therefore considered worse as depicted in the comparison.*

The results of the following comparison should be only used by considering the limitations above.

71. Around 70%.
72. EU average around 75%.
73. I.e. inclusion/exclusion of interruptions recorded at EHV/LV level in different sets of indexes.
74. The contribution of interruptions that could be attributed to the transmission exceeds the EU average.

2.4.3 Unplanned Long Interruptions - All Events

Data on continuity of supply indicators including all events, i.e., without removing exceptional events from the statistics, is shown in Figure 1[75].

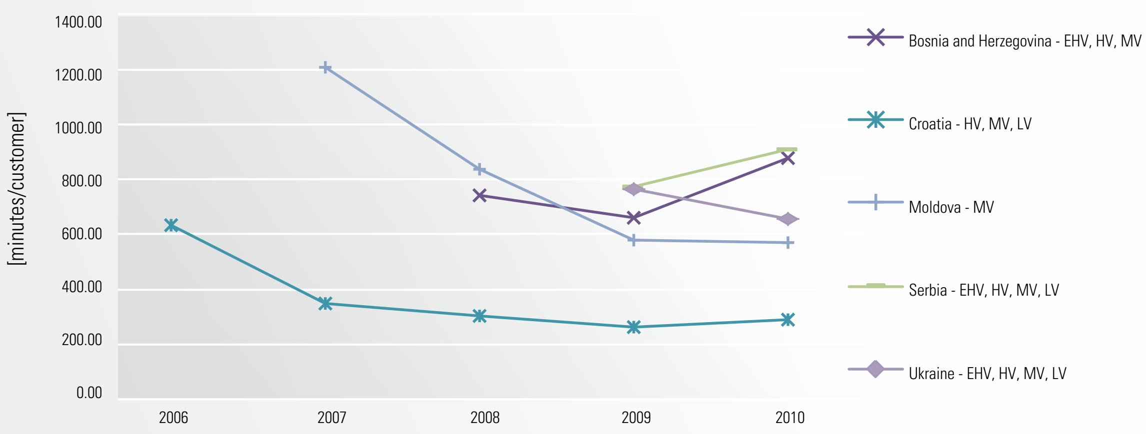
It is important to consider the fact that the compared indicators also comprise interruptions recorded on different voltage levels. Especially when interruptions on LV are not considered, the real level of continuity of supply is for sure worse than depicted. In average about 80% of faults occur on MV level, so comparison is still reasonable.

It is interesting that the values do not show any larger year-to-year variations (usually caused by exceptional events). Only Moldova and UNMIK exclude exceptional events from their statistics. Therefore, the continuous improvement of SAIDI in Moldova may indicate that the level of continuity of supply has been systematically improved during the last 4 years. In the other CPs SAIDI trends are quite stable.

In general, **the range of values for minutes lost extremely differs between the 6 CPs**, with the lowest SAIDI of 261 minutes per year in Croatia (2009) and the highest value of 5739 minutes per year for UNMIK (2010). Due to the extreme deviation of UNMIK and only one value provided, UNMIK is neglected in the following analysis. The modified range of minutes lost in the remaining 5 CPs is between 250 and 1000 minutes per year. SAIDI values of Croatia, Moldova indicate systematic improvements, as well as no impact of exceptional events, while SAIDI values of Bosnia and Herzegovina varies from year-to-year up to 30%. Such variation may indicate the influence of exceptional events on the statistics, but no explicit information is available for proof. Serbia and Ukraine provided data only for 2009 and 2010 which is not enough for a serious conclusion. The value of SAIDI reported by Serbia for 2009 comprises interruptions for 4 out of 5 DSOs.

Considering all facts, it can be concluded that **on average there is an improvement of the index SAIDI in the CPs** and that the statistics were not influenced by the exceptional events in bigger extent.

Figure 1 | Unplanned long interruptions including all events, SAIDI (2006-2010)



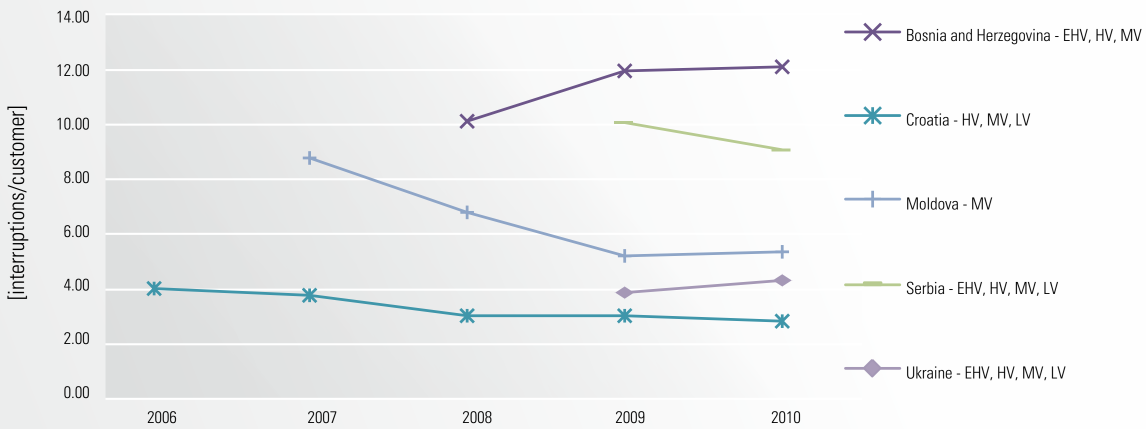
Note: The voltage level (LV, MV, HV, EHV) is related to where the incidents occur.

75. The minutes lost per customer per year, with all interruptions included in the statistics.

Figure 2 shows the number of **interruptions per year** with all interruptions included in the statistics. The range of interruptions in the 5 CPs that contributed data, is between 3 and 12 interruptions per year[76].

For Croatia and Moldova, SAIDI varies slightly more than SAIFI from year to year. Extreme events influence SAIDI more than SAIFI. Therefore, the level of continuity of supply has not been considerably affected by exceptional events since SAIDI and SAIFI of both countries closely correlate.

Figure 2 | Unplanned long interruptions including all events, SAIFI (2006-2010)



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

2.4.4 Planned Long Interruptions - All Events

The minutes lost per customer due to planned interruptions is presented in Figure 3. The values show **a wide spread between the CPs**, from approximately 250 to 850 minutes per year.

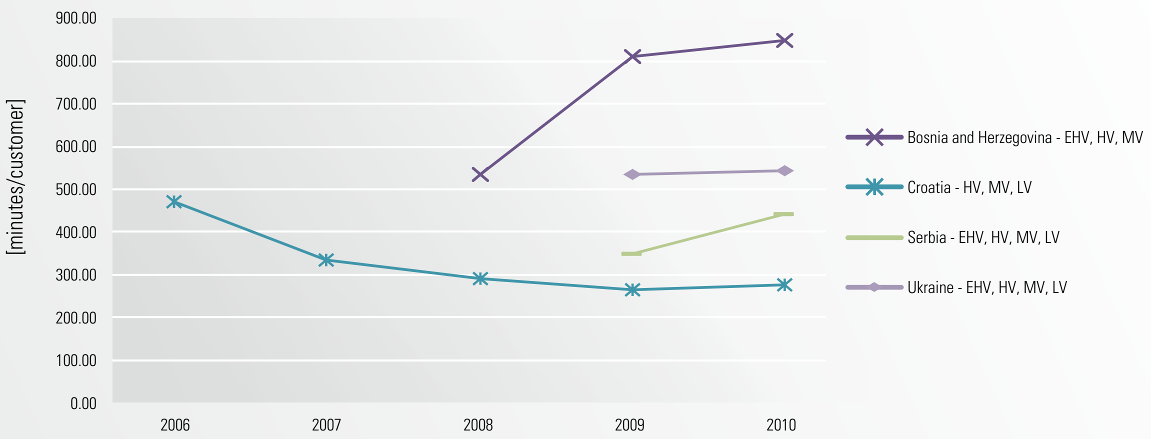
Not all CPs that provided data include interruptions due to planned maintenance on all voltage levels in their statistics. While – due to the network design - planned interruptions at EHV should have no bigger impact on continuity of supply, planned interruptions on LV significantly influence statistics. Planned interruptions on LV are not included in the values for Bosnia and Herzegovina.

No trends can be identified from the figure; a big increase of planned SAIDI over the last 3 years is visible in Bosnia and Herzegovina, whereas in Croatia we observe a reduction of the minutes lost due to planned interruptions.

The identified differences between CPs may be caused by differences in distribution network design, differences in the amount of maintenance and investments, differences in the replacement and repair of components that were provisionally restored after exceptional events or widespread replacement of equipment.

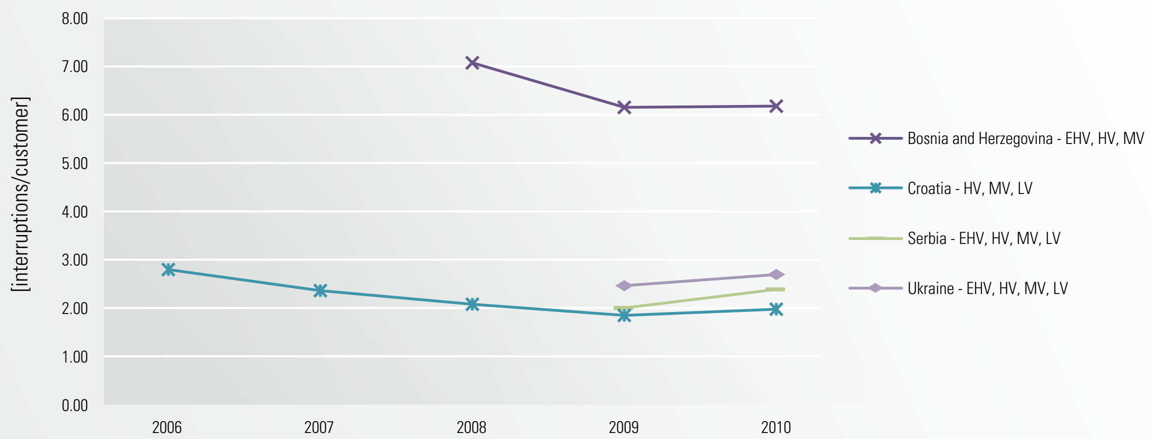
76. The SAIFI for 2010 provided by UNMIK has been removed from comparison for the same reason as above.

Figure 3 | Planned interruptions, SAIDI (2006-2010)



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

Figure 4 | Planned interruptions, SAIFI (2006-2010)



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

The share of minutes lost of planned interruptions in total interruptions (planned and unplanned) has been calculated for all CPs that provided data (see Table 36). It can be concluded that **30% to 55% of all interruptions are planned and notified in advance**[77]. The share of planned interruptions in total interruptions (planned and unplanned) is lower (about 15%); maintenance affects the duration more than the number of interruptions.

It is hard to evaluate the reason behind certain values of the share of planned interruptions in total interruptions: higher values could indicate massive facility program maintenance[78] or bigger investments in the network aimed to target better quality in the future. Lower values may indicate low scope of maintenance/investments or good quality of existing networks.

It is interesting that the share of planned interruptions in overall statistics[79] almost does not vary over the observed years. Minutes lost due to planned interruptions remain in correlation to unplanned minutes lost. This is an **indication that there were no dedicated massive maintenance or investments campaigns performed**, but rather regular maintenance that correlates with unplanned incidents.

77. Assumption.
78. Due to poor network status.
79. Especially minutes lost, but also the number of interruptions, see Table 35 and Table 36.

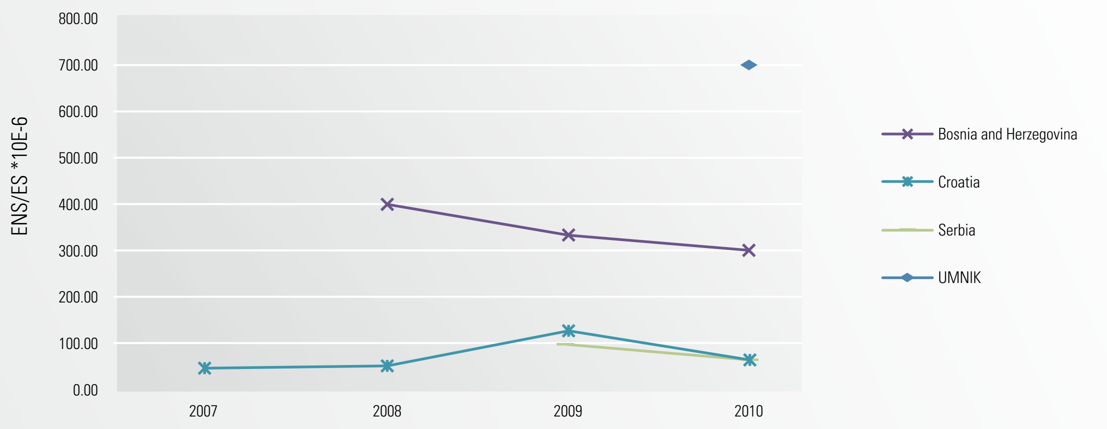
2.4.5 Continuity of Supply on Transmission Level

Indices like ENS provide a somewhat better indication of the consequences of an interruption on EHV/HV than the indices SAIFI or SAIDI. It should be kept in mind, however, that the underlying assumptions are an extreme simplification of the actual consequences of interruptions. As there is no energy consumption during interruptions, it is not possible to exactly measure the energy not supplied. Estimations can be based on power withdrawal just preceding the interruptions, load profiles in the previous hours / on the previous day / on the previous same weekday / on the same day of the previous year on special calendar days, depending on the duration of the interruption.

It should be further 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.

In Figure 5 the most commonly used indicator ENS, normalized by energy supplied[80], is shown for the CPs that provided data. The indices provided do not exclude exceptional events. The values of ENS are provided in Table 38, and the data on related AIT is shown in the Table 37.

Figure 5 | Normalized ENS by energy supplied for transmission system



80. The transmitted/distributed energy to all customer from the "System Data" section of the questionnaire is used for this purpose.

2.4.6 Network Characteristics

An overview on available system data of particular CPs is given in the table below. The networks largely vary between the CPs as regards their size and structure.

TABLE 16 | Information on network, equipment, energy supplied, number of customers

SYSTEM DATA	Measure unit	Bosnia and Herzegovina	Croatia	FYR of Macedonia	Moldova	Serbia	Ukraine	UNMIK
Item # 1 - Length of networks		**2010**	**2010**	**2010**	**2010**	**2010**	**2010**	**2010**
Total length of circuits - EHV network	km	2390	2520	611	580	3395	20737	414
Total length of circuits - HV network	km	3919	4830	1666	5292	6054	50387	722
Length of cable circuits - MV network	km	4329	14766	2984	2139	11039	52772	1014
Total length of circuits - MV network	km	24844	40436	11368	23498	49275	437274	7164
Length of cable circuits - LV network	km	4953	26535	3279	1822	11983	40611	486
Total length of circuits - LV network	km	66269	93675	14599	32249	107072	487494	11990
Item # 2 - Energy								
Transmitted/distributed energy (all customers)	TWh	11,47	15,70	8,10	3,92	28,00	146,40	5,46
Distributed energy (only MV and LV customers)	TWh	8,14	14,70	5,17	3,23	25,50	107,07	2,76
Item # 3 - Customers								
Number of MV connection points of final customers	number	1458	2078	1211	3664	3970	1313019	236
Number of LV connection points of final customers	number	1401751	2312959	654627	1275687	3495433	18577018	354888
Item # 4 - Equipment								
Number of MV feeders starting from HV/MV or EHV/MV transf. Stations	number	2590	1910[81]	13 (110/x kV Transformer stations are with SCADA in distribution)	5282	614		110
Number of MV feeders equipped with remote control (SCADA)	number	NA	1910[82]	8 (35/10 kV Transformer stations are with SCADA in distribution)	1677	N/A		N/A
Item # 5 - General info								
Number of DSOs	number	7	1	1	3	5	44	1
Customers served by the largest DSOs	number	698828	2312959	655838	812553	919910	1913235	419220
Customers served by the three largest DSOs	number	1126320	2312959	655838	1279351	2620430	4641392	

Note:
- Total length as sum of length of underground cable circuits, bare overhead lines and insulated overhead lines (overhead cables).
- Distributed energy excluding self-consumption.

81. Estimation based on the number and type of substations.
82. Estimation based on the number and type of substations.

Most CPs extended the length of their networks over the past 5 years, except of Ukraine where the length of MV and LV networks has decreased slightly (Table 29). The majority of investments were focused on cable networks (MV and LV), adding different length but in general up to 20% since 2006. An **increase of the number of connection points** is also observed. Accordingly, the transmitted and distributed amount of energy also increased. The only exemption, again, is Ukraine where consumption decreased.

2.4.7 Correlation between Continuity of Supply and Network Characteristics

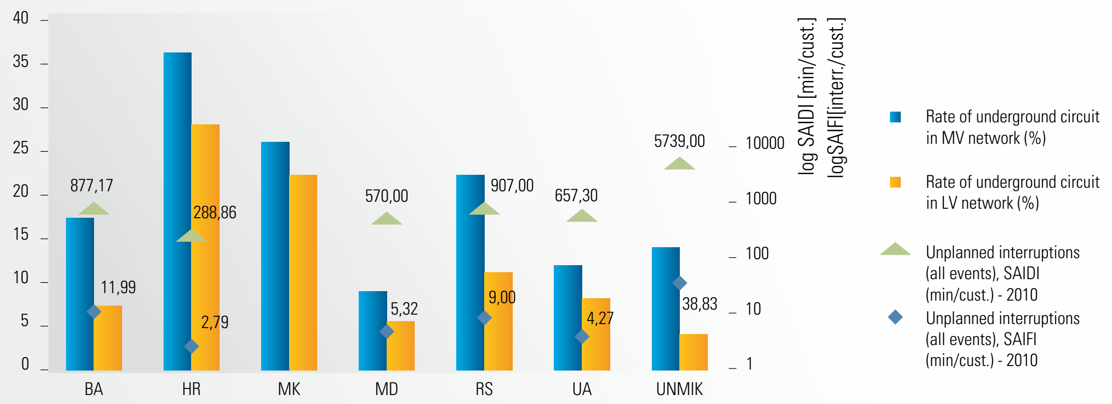
The discussion on the correlation between the levels of continuity of supply is based on the following proven facts, based on practical and theoretical experiences in the EU, namely:

- The interruption frequency is directly proportional to the length of the feeder protection zone;
- The probability of an outage in cable networks is approximately 10 times lower than in overhead networks; and
- The rate of underground circuit has larger impact on SAIFI than on SAIDI.

The average length of feeders is not known, so the discussion is tackling the relation between the percentage of underground cables and the achieved level of continuity of supply only.

It is obvious that **the average rate of underground circuit on both MV and LV networks are much lower in the CPs compared to the EU[83]. Therefore the level of continuity is expected to be much lower as well.**

Figure 6 | Correlation between SAIDI and SAIFI and the rate of undergrounding in MV and LV networks



Croatia, with the highest percentage of underground circuits (on both LV and MV levels), also reported the best level of continuity of supply expressed by SAIDI and SAIFI. It is surprising that the difference is bigger in duration (SAIDI) and not as much with frequency of interruptions (SAIFI). Moldova reported second best level of continuity with the lowest rate of underground circuits (lowest at MV, second worse in LV). The correlation between undergrounding and SAIFI for Bosnia and Herzegovina, with the worse unplanned SAIFI reported, is supportive to the statements above (data for UNMIK was neglected for better comparison).

Due to unavailability of a wider range of year-to-year data, the discussion on other CPs as well as on statistical correlations is not feasible.

2.5 On-Site Audits on Continuity Data

In this section only on-site audits are included. It is, however, expected that regulators may also carry out so-called desktop ("off-line") audits in order to ensure most correct data on continuity of supply.

Only two of the surveyed CPs regularly execute on-site audits on continuity data provided by

83. 1.0:3.6 for LV and 1.0:1.8 for MV.

the companies, namely Bosnia and Herzegovina and Ukraine. The relevant on-site audit is conducted by the regulatory authority.

In Bosnia and Herzegovina, the procedure of collection and processing of interruptions has been audited on-site[84] once per year by the RA since 2008; compliance with the document that defines the monitoring procedure of the licensees for distribution of electricity prescribes, among others, the quality of supply monitoring requirements. If the audit closes with negatives results, a decision on the measures to be taken is made.

Moldova reports that auditing is foreseen but that a formal methodology has not yet been developed and applied.

In Ukraine, the reports and electronic registers submitted to the RA (by 44 utilities) are subject to on-site audits are conducted once per year by the RA. Penalties are foreseen, rules on auditing are currently in preparation.

The other analysed CPs have not yet designed audit procedures but are interested in implementing such procedures in the future according to the development of their service quality regulation frameworks.

2.6 Continuity Standards and Incentive Schemes

The following section provides an overview of the existing frameworks of continuity of supply regulation in the CPs. It will also illustrate which indicators and standards are used in this regard.

In the subsequent sections different terminology is used for the required performance defined by the RAs by means of setting the targets on continuity at the system level:

- continuity standards set on system level;
- overall (continuity) standards;
- (average) required performance; and
- (average) performance targets.

While some of the terms are not frequently used, some have a sound basis in the documents of the European Energy Regulators[85]. However, harmonisation has not been achieved yet.

The regulation frameworks are assessed on two different levels:

1. Continuity standards at system level with the quality reward/penalty regimes;
2. Continuity standards at single-customer level with the customer compensation schemes.

The development of regulation frameworks in the CPs is on an initial stage in the prevailing number of cases. The main emphasis is put on continuity monitoring. However, from the responses provided, it can be concluded that activities for assuring maintenance and improvement of continuity levels, as well as activities for protecting the worst served customers are ongoing or will start soon. Two CPs, namely FYR of Macedonia and Montenegro, reported 2012 as a milestone for the first implementations of more comprehensive frameworks. It can be expected that the other CPs will follow and developed their frameworks till 2015.

84. 1 TSO, 7 DSO.
85. I.e. papers on "Smart Grids: Position Paper on Smart Grids" http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Smart%20Grids/CD and "CEER status review of regulatory approaches to smart electricity grids" http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Smart%20Grids/CD/C11-EQS-45-04_SmartGridsApproach_6%20July%202011.pdf

TABLE 17 | An overview on existing continuity standards and incentive schemes

Standards and regulation	Overall standards	Individual standards	Overall reward/ penalty scheme	Individual compensations
Distribution	Moldova, UNMIK	Moldova, Montenegro[86], Serbia[87]	Moldova	Moldova
Transmission	UNMIK	Moldova, Serbia	-	-
Definition of worst served customer	-			
Responsibility	Albania, Bosnia and Herzegovina, Moldova, Montenegro, Ukraine, UNMIK (RA); Croatia, FYR of Macedonia, Serbia			
Publication of indices	Albania (monthly), Bosnia and Herzegovina, Croatia, Moldova, UNMIK (annually)			
Intention/plans for implementation	FYR of Macedonia, Montenegro (2012), Serbia (2013-2015), Ukraine (ongoing)			

No explicit regulatory or other definitions of worse served customer are applied.

Not all CPs publish data on indicators, but wherever applied they are published mostly on annual basis. Only Albania reported monthly publication.

Moldova has developed the most comprehensive framework: individual (customer based) and system standards are set and, accordingly, the compensation scheme and reward/penalty scheme are applied as well. The reward or penalty schemes or other incentives to optimise the continuity of supply levels have not yet been introduced in the other CPs.

Moldova - standards and inventive schemes

System level:

The Moldova penalty scheme was introduced by the law of electricity. If a company does not respect the established levels of quality indicators (not only for continuity of supply), the RA has the right to reduce the tariff for distribution or for transmission up to 5% for one year.

SAIDI for the next 4 years:

- 2011: 600 minutes/customer;
- 2012: 550 minutes/customer;
- 2013: 500 minutes/customer; and
- 2014: 450 minutes/customer.

The scheme is based on penalties only. A socioeconomic or optimal level of continuity of supply has not been estimated as basis for the quality regulation; instead, a regulated level was established taking into account the actual level of SAIDI and real situation of the distribution networks.

The tolerance band is set by Regulation and approved by the RA. For example, if the regulated level of SAIDI for the year 2011 is 600 minutes (except for exceptional events), the penalty will be only applied if the real level of SAIDI for a DSO will be 630 minutes or more. The tolerance is therefore 30 minutes and will remain constant for the next 4 years (2011-2014). The incentives (penalties) are proportional to the difference between the actual performance level and the standard (or target), if the deviation is:

- from 30 to 120 min – the penalty is 0,2% of the tariff (minimum);
- from 121 to 180 min – 0.5%; and
- more than 180 min – 1% (maximum).

Individual level:

The following individual standards are set:

A) The duration of one planned interruptions shall not to exceed:
- 2 hours, in case of executing works for new connections at LV level;

86. Individual standards: for individual large industrial customers (e.g. KAP-Aluminium Plant) connection to 110 kV in which technical processes require special conditions regarding continuity and quality of supply.
87. Defined by the Decree on Conditions for Electricity Delivery and the Grid Code.

- 4 hours, in case of new connections, reconnections at MV level;
- 12 hours, in case of works for prophylaxis, current repairs of electric equipment etc.; and
- 24 hours, in case of a capital repair of electric lines.

B) The duration of one unplanned interruptions shall not to exceed:
- 24 hours, where it is necessary to repair or replace a damaged electric line sector[88];
- 16 hours, for interruptions, produced at nighttime and caused by defects of MV networks;
- 6 hours in urban areas and 8 hours in rural areas in other cases.

C) The annual number of planned interruptions:
- 5 for urban areas and 8 for rural areas.

D) The annual number of unplanned interruptions:
- For urban areas – 6 (at MV level) and 9 (at LV level); and
- For rural areas – 9 (at MV level) and 12 (al LV level).

E) The annual duration of unplanned interruptions:
- For urban areas – 36 hours; and
- For rural areas – 48 hours.

Compensations payments are differentiated in 3 groups:
- Household customers;
- Non-household consumers, under installed power less than or equal to 100 kW; and
- Non-household consumers, under installed power higher than 100 kW.

The compensation level has been set taking into account the experience of other CPs[89] and also considering the level of salaries. The compensation level is capped. The compensation payments are issued per request. Exemptions from compensations are as well defined:

- force majeure situations;
  - events caused by end consumers' installations, emergencies at interconnection lines;
  - special meteorological conditions;
  - in the case of electricity supply interruptions caused by third parties; and
  - in the case of unscheduled interruptions exceeding 3 minutes.

Montenegro protects special large industrial customers only by individual standards on continuity of supply. Serbia also applies individual standards and set minimal requirements on duration of interruptions but no compensation scheme.

Serbia - standards and inventive schemes

Individual level: The *Decree on Conditions for Electricity Delivery* defines that each unplanned interruption of electricity delivery has to be restored to the customer within 2 hours, and maximum within 72 hours in case of force majeure or some other exceptional event.

The *Grid Code* issued by the TSO defines that each connection point shall not be affected by unplanned interruptions of supply due to a cause in the transmission network for longer than 2 hours/year for the generation connection point, 4 hours/year for the other connection points in the HV (400/220/110 kV) network and 6 hours/year for the connection points in the MV and LV network.

Also in UNMIK overall standards on continuity of supply were applied in 2011.

UNMIK - standards and inventive schemes

System level: for 2011 the following overall standards on CP level have been set - SAIDI shall not exceed:

- twenty (20) hours of planned interruptions per customer; and

- thirty (30) hours of unplanned interruptions.

The economic effects and outcomes of the regulatory actions cannot be addressed, since no data is available.

88. Several damaged or fallen posts, defects of underground cable lines or a powerful transformer.
89. Ex. from benchmarking reports on quality of electricity supply.

2.7 Expected Developments on Continuity of Supply Regulation

Regulation of continuity of supply will be for sure subject to further changes and developments in the future. Those CPs that have not implemented related rules yet will do so, while others will focus on improving their regulations. Making use of the experience and good regulatory practice within the EU will be of great help to the CPs.

Bigger improvements are expected for the period from 2012-2015: there are plans to define minimal continuity standards and strengthen regulation in FYR of Macedonia, Montenegro and Serbia. Ongoing developments are also reported for Ukraine. Also the other CPs are working on a more comprehensive approach on regulating continuity of supply, some analysing the possibility of introducing a reward-penalty mechanism[90].

All observed CPs have initially put emphasis on the improvement and assurance of the preconditions for the regulation of continuity of supply. Monitoring of continuity of supply on all levels with the highest level of detail, backed up with harmonised and standardised rules shall be wrapped up with the continuous publication of data. The transparency of the achieved level of continuity of supply is the very first step of a long journey towards better regulation.

2.8 Findings and Recommendations on Continuity of Supply

Monitoring is applied in all CPs that participated in the survey. As a first objective pursued by the regulators and as the core component of the service quality regulation framework, monitoring has widely reached a phase that can start to back-up regulatory decisions successfully. Different approaches to the regulation - driven by CP legal frameworks and, in particular, different monitoring methodologies used, combined with different geographical, meteorological characteristics, different networks structures and age - make benchmarking of actual levels of continuity of supply difficult.

A comparative analysis of the monitoring schemes and the continuity of supply regulation in the CPs shows that **regulators have generally approached continuity issues with emphasis on long interruptions first, treating the planned and unplanned interruptions separately. Distinction is made between different voltage levels and the reasons of interruptions. In several CPs both the number and duration of interruptions are available and almost harmonised combinations of indicators (SAIDI, SAIFI) are used. Short interruptions are barely recorded.** Few examples of regulatory practices on advanced regulation instruments are identified in the region as well by means of continuity standards and incentive schemes.

Monitoring schemes are developing and are currently in different development stages:

- monitoring is focused mostly on long interruptions;
- monitoring on transmission level is not applied in all CPs[91];
- monitoring is performed in different detail levels;
- different sets of indicators are used, although basic indicators (i.e. SAIDI, SAIFI, ENS) are widely used; and
- not all incidents are considered in the statistics (i.e. LV).

A lack of harmonisation of the basic monitoring rules is also identified, but it is not predominant. The lack of emphasis on monitoring of continuity on transmission level in some CPs may be the result of underestimation of its importance due to the robust network design enabling high reliability ("n-1" operational criteria), the apparently low number of customers connected to the transmission network, problems of weighting and the estimations (i.e. "ENS" based indices).

All CPs are encouraged to strengthen their efforts on further developing and optimising their monitoring process and make further steps towards comprehensive and robust monitoring schemes. The transparency of data and its quality is essential.

90. Link between the continuity and tariffs.
91. Atypical customers, specifics in calculation of certain continuity indexes.

The findings and recommendations are provided as follows.

Finding #1

Rules, business processes and tools for automatic logging of interruptions are not applied in all CPs

Many CPs reported only limited use of SCADA and prevailing manual recording of interruptions is applied. Lack of rules for automatic recording of interruptions has a direct impact on completeness, robustness and the quality of data. Decisions taken (by the regulator or the system operator) on the basis of such data may be misleading. Also auditing such data is time consuming and not efficient.

Recommendation #1

Efficient rules for automatic logging of interruptions have to be introduced

Implementation of SCADA and its Distribution Management System (DMS) functions that to a larger extent enable automatic logging (at least for EHV, HV and MV voltage levels) is crucial for efficient monitoring of continuity of supply.

It is recommended that all CPs define rules for automatic logging of interruptions. These rules on recording should be harmonised. Deviations or CP specific rules can be upheld.

Finding #2

Harmonisation of interruption definitions is not achieved - monitoring schemes lack comprehensiveness and efficiency

Some minor differences in definitions of interruptions exist. However, only Albania has a completely different classification for the duration of interruptions. Available standards (EN 50160) and guidelines of good practice[92] are widely not used.

Not all types of interruptions are monitored. Only two CPs reported that monitoring of short interruptions is applied and performed in a limited scope, i.e. Bosnia and Herzegovina and Ukraine. Transient interruptions are not monitored by any of the CPs.

The monitoring schemes are lacking efficiency. The main problem lies in the way how interruptions are recorded – in the absence of SCADA or Advanced Metering Infrastructure (AMI) (i.e. for recording the interruptions on LV), manual logging of interruptions and data processing does not assure the required efficiency and reliability of data.

Finding #3

Recommendation #2

Monitoring of all basic interruptions types should be introduced, based on harmonised definitions

It is recommended to harmonise their definitions for basic interruption types (firstly long, secondly short and, if justifiable, transient). Available norms and examples of good practice could be used as a basis for this harmonisation process.

Harmonisation should be introduced for:
- long interruptions > 3 min;
- short interruptions > 1 s and ≤ 3 min; and
- transient interruptions ≤ 1 s.

As such, the definitions of interruptions should be aligned with the definitions of EN 50160, as well as with European practices.

Short interruptions do not only have negative impact on households but also business and industrial customers and should therefore also receive appropriate attention by the regulators.

The fact that SCADA will still be need to be implemented in many CPs from scratch provides a good opportunity for the CPs to plan appropriate SCADA functions and the appropriate of network coverage by SCADA to ensure automatic recording of short interruptions. SCADA is usually implemented starting at the highest voltage level, moving to the high-load-density parts of the lower-voltage levels. Short interruptions mainly occur in the low-load-density parts of the lower-voltage levels. This important technical issue needs to be considered when planning the introduction of SCADA. The costs needed for such a comprehensive monitoring scheme will be lower in comparison to an upgrade of existing SCADA functionalities. It is important for CPs to consider all related aspects; among those are rules for aggregation of interruptions that occur in a short time span.

RAs should also decide on the extension of monitoring schemes for transient interruptions.

92. CEER, 4th Benchmarking report on Quality of Electricity Supply, 2008; http://www.energy-regulators.eu

Continuity statistics do not include incidents at all voltage levels

None of the CPs has established efficient monitoring schemes for recording interruptions on all voltage levels.

While interruptions are recorded separately according to the particular voltage level in most CPs, monitoring is not always performed on all voltage levels. Usually, data is collected on HV and MV level only but LV is not been sufficiently covered yet[93].

The lack of monitoring or inefficient monitoring on LV[94] level could result in a significant underestimation of the number and duration of interruptions experienced by low voltage customers (unplanned and planned), especially in urban areas but also on CP level. Indeed, even if incidents on LV will affect much less customers than incidents on MV and higher voltage levels, incidents on LV cannot be neglected: the resulting interruptions often last longer[95] than interruptions due to incidents at higher voltage levels and are also significant in number.[96] The SAIDI contribution from LV, therefore, might be even underestimated.

Recommendation #3

Interruptions should be also monitored on LV Level

It is recommended that the measurement of interruptions should cover all network levels.

All CPs are encouraged to include monitoring of interruptions at all voltage levels including LV in the continuity of supply statistics. A cost-benefit analysis should be performed to evaluate the different possibilities:

- automated recording based on AMI;
- development of methods for estimation of duration and number of affected customers (i.e. using call centres); and
- other (i.e. protection equipment in LV feeders under supervision of SCADA).

Wherever manual logging is applied, system operators should be more vigilant regarding manual entries of outages in LV networks. This can be supported by appropriate organisational and technical measures.

93. The EU made similar experience in the past.
94. Which are all domestic customers and the majority of non-domestic customers.
95. LV networks are usually radial networks without redundancy.
96. According to the experience of some EU countries, the contribution of interruptions from LV to the continuity indicators (SAIFI and SAIDI) varies between 7% and 30% on country level - this analysis is based on the evaluation of impacts of incidents on LV networks that are mostly estimated based on notification via phone calls (AMI is not installed).

Finding #4
Categories of interruption causes vary between CPs

Information on interruption causes is essential for DSOs to improve continuity of supply but also for RAs to identify and approve appropriate investments in time. Such information should be collected by system operators as detailed as possible. There is no need for harmonisation of the specific reasoning types but it may be useful to achieve harmonisation of the main categories. Especially, the treatment of so called "third party" causes is sometimes mixed with the category "exceptional events".

Recommendation #4

Harmonisation of Basic Cause Categorization

The harmonisation of basic cause categories between the CPs is recommended. Also, a clean split between third party and exceptional events categories is highly recommended.
We recommend **the use of the following three main cause categories**:

1. responsibility of system operator;
2. third party; and
3. exceptional events.

Each interruption cause (not necessarily harmonised) shall be linked to the appropriate category. The use of causes like "other", "not available", "unexplained" as main categories should be avoided as much as possible. Such causes may be only used as sub-types.

Among the interruption causes in the category "third party", the responsibility of another system operator for an interruption should be specifically identified in the monitoring activity with a view to make them easily identifiable.

The distinction between the main cause categories[97] shall be achieved by clear definitions.

Finding #5
Level of detail in calculating continuity indicators differs between CPs

6 CPs provided data on continuity indicators. This allows an initial benchmarking. Two third of the CPs that provided at least 3-year data (2 out of 3) show a decreasing unavailability (SAIDI). However, due to the fact that continuity is benchmarked by using indices that include exceptional events and that explicit information on such events was not provided, any conclusion on trends would be misleading. More historical, year-to-year data would be needed for an in-depth analysis.

Calculation on the level of individual system operators, region and area is not common practice in the CPs. Only two CPs calculate indices in such detail. Also, only 4 CPs reported that they calculate indices per network type (according to the population density); among them, only 3 CPs provided data on related indices. In each of these CPs, the continuity of supply is much better in urban areas than in rural areas.

The lack of disaggregated CoS data creates a barrier for RAs' and system operators' decisions on necessary measures. Undergrounding is a good example of possible measures for improvement of continuity: although the best level of continuity in the region (using the aggregated data) clearly correlates with the highest rate of underground network (Croatia), the same correlation should be assessed using disaggregated continuity data (i.e. SAIDI and SAIFI covering interruptions at certain voltage level only) to strengthen the findings.

97. To avoid mixing the "third party" and "exceptional events".

Recommendation #5

Logging of interruptions shall comprise all necessary details to enable disaggregated calculation of continuity indices

Network operators should use an extended set of interruption properties[98] when recording and post-processing interruption data. Such comprehensive approach enables the calculation of disaggregated indices. For that purpose, system operators should meet the technical preconditions for obtaining such data and implement the appropriate business processes for backing up the necessary post-processing of data.

System operators should be required to provide aggregated and disaggregated continuity data (on voltage levels, network types, etc.) to the RA.

For RAs it is important to calculate the indices per system operator with a view to benchmark their performance and identify possible larger continuity of supply differences.

The calculation of indices according to the network type (rural/suburban/urban networks) provides essential information for decisions on measures for improvement of continuity of supply. It is therefore **recommended that indicators are calculated for each system operator separately as well as according to the population density** (urban/suburban/rural). The latter requires the rules for classification that may not be harmonised, due to differences in the network structure and geography, as well as demographic characteristics of CPs. Non aggregated calculation of indices will ensure more flexibility for RAs when designing regulatory incentive schemes[99].

RAs are encouraged to continue monitoring of CoS based on an extended set of indicators. Historic data, aggregated and disaggregated data (on voltage levels, network types, etc.) is essential for identifying trends and performing correlation analyses. Monitoring scheme should evolve in a way to assure CoS data for wider time-spans, as well as in greater detail: disaggregated data should be calculated in order to identify problems and direct priorities.

Finding #6

Lack of explicit information on the use of concepts of "exceptional events" hinder the impact analysis of "exceptional events" on the level of continuity

Some interruptions are considered to be due to exceptional events and are therefore either not reflected in the continuity statistics or are treated separately. From the information available, it is hard to evaluate the real use of the concept of "exceptional events", even if its application is widely reported by CPs. Different CPs use different criteria for defining an interruption as exceptional event.

Where exceptional events are displayed in the statistics, knowledge on the contribution of exceptional events is of utmost importance when analysing continuity of supply data. Although concepts of "exceptional events" are reported to be applied, the impact of exceptional events is not clear – the estimated contribution of exceptional events is more or less constant. This indicates that the concepts of "exceptional events" are not properly defined or used – exceptional events may also include interruptions due to weather circumstances that occur once a year or more often (as lightning etc.).

98. Control area, i.e. population density (urban/suburban/rural), voltage level, network type (cable/overhead), cause, sub-cause etc.
99. For example the differences in the level of continuity of supply according to the population density should be considered when applying the minimal continuity standards.

Recommendation #6

Proper use and transparency of concepts of "exceptional events"

The possibilities for harmonisation of definitions on exceptional events should be explored. It is **recommended that CPs harmonise the definition by means of the common characteristics of the natural and non-natural exceptional event**. An exceptional event t is beyond the control of the system operator and is characterized as:

1. unforeseeable;
2. unpredictable;
3. unpreventable;
4. unavoidable.

All four event characteristics must be confirmed for the event to classify as "exceptional". Furthermore, the weather circumstances that occur once a year or more often should not be considered as exceptional events. Lightning should not be treated as an exceptional event anywhere in the Energy Community (it is foreseeable and predictable event in all CPs).

The CP specifics aggravate the harmonisation in further detail[100]. **Harmonisation in such detail is not feasible**.

Until adequate harmonisation has been achieved, it is recommended for each CP to transparently use the definitions and designations of their own regulation. The use of expressions, such as "exceptional events", with an apparent intuitive meaning but without a clear definition of the manner in which it is used can result in misinterpretation.

Network operators should appropriately and reasonably minimise effects of events that are outside of their control, in line with appropriate regulatory schemes.

Finding #7
The set of indicators used does not provide a complete picture of Continuity of Supply

Most of the CPs calculate SAIDI and SAIFI (some also MAIFI) for distribution networks and ENS (also AIT) for transmission networks. The main interruption properties (duration and frequency) are therefore covered on distribution level only.

Some CPs do not calculate indices for transmission, some use of (rough) estimations when calculating indices. Besides, indicators that express the level of continuity in terms of interruption frequency in transmission networks are not calculated.

Recommendation #7

The number of continuity indices used should be extended

The use of multiple indicators to quantify CoS provides more information and, therefore, more possibilities to observe trends. **Frequency and duration should be monitored from different aspects, using different indicators.**

CPs are encouraged to gradually extend the set of continuity indicators. For a balanced view on the achieved level of CoS, indices should always cover both duration and frequency of interruptions. The recommended set could be SAIDI, SAIFI, MAIFI for distribution and ENS, AIT, SAIFI and MAIFI for transmission. The following transmission user types can be used for the calculation of SAIFI and MAIFI (transmission):

1. using three types of transmission users: HV transformation stations (counted each as 1 user, independently from number and size of transformers installed), HV/EHV final customer (large industry) and producers connected to transmission grid); or
2. using the whole number of the affected network users (on transmission and all lower voltage levels (distribution).

Whenever the first option is chosen, the results should be accompanied by information on the weighting method. Also, the aggregation of the indicators calculated using different user types (i.e. on transmission and distribution levels) should be avoided.

The minimal set of indices used for measuring the level of continuity of supply on distribution and transmission level should be harmonised.

100. For example, if snowstorms are not an exceptional event in the northern CPs, it could be seen as an exceptional event in southern parts of the Energy Community".

Finding #8
Publication of continuity data is not performed in all CPs and differs on details

Publication of continuity data is not performed by all CPs. Also, the frequency of reporting varies between the CPs. Publication of continuity data usually does not consider exceptional events.

Recommendation #8

Publication of continuity data on regular basis with explanatory notes

Publication of data is one of the primary regulatory instruments and should be executed as soon as data is available. Published comparison of company performance is very effective, stimulates a competitive environment and encourages companies to make improvements. Comparisons on supranational level are useful for RAs in the process of developing and improving their quality regulation schemes and CP related performance.

It is recommended that system operators publish CoS data regularly but at least once a year. System operators should also provide explanatory notes on the data published.

RA should also regularly publish CoS data aggregated on CP level, including remarks regarding system operators' performance.

It is recommended for any publication of continuity of supply data to include information on the included and excluded interruptions together with information about those situations that are treated specifically. This especially applies to exceptional events.

In case of exclusions disaggregated CoS data should be provided for regulatory purposes.

The cooperation and the exchange of experience between the CPs via the ECRB provide helpful support. The examples of good practice and lessons learned on EU level should also be considered.

Finding #9
Only a couple of CPs perform audits of CoS data

Only two CPs apply "on-site" or desktop auditing procedures on reported data.

The credibility of the continuity of supply regulation primarily depends on the consistency and accuracy of data (quality of data). The main objective of the audits therefore is to verify whether regulated companies are correctly applying the instructions and guidance for measuring and reporting of data. Furthermore the minimal level of accuracy while performing the monitoring is verified.

In case audits are not performed, the quality of data is not verified and the use of such data is therefore questionable.

Recommendation #9

All CPs should carry out audits of Continuity Data

It is crucial that all CPs implement and apply audit procedures as soon as the monitoring scheme (rules, procedures, sets of indicators etc.) is stable and in place.

Finding #10
Minimal continuity standards and incentive schemes are rare and use different formulations

The regulation frameworks in CPs are mostly in an initial stage. Therefore, incentive schemes on system level (reward/penalty schemes based on overall continuity standards (references) influencing the tariff) or individual level (guaranteed standards with the compensation payments to customers) are rare. According to the maturity of the continuity regulation, such status is not uncommon and expected. The few schemes that are applied are not similar and are rather simple.

Recommendation #10

Gradual implementation of incentive mechanisms

The examples of reward/penalty regimes already applied for several years in many countries of the EU show their positive impact in improving or preserving the level of continuity of supply. **It is therefore recommended that CP develop reward/penalty regimes taking into account the CP specific conditions**[101]. The development of regulation should be gradual and the prerequisites for incentive schemes at any level should include a robust monitoring scheme and audits. It is recommended that **a step-by-step approach** is used in setting minimal standards on continuity of supply. Robust historical data is a prerequisite for such decisions.

Gradual implementation of minimal standards (in the form of overall and guaranteed standards) will encourage the development of different incentive mechanisms (reward/penalty schemes and/or compensation payments) to maintain and further improve the level of continuity supply.

101. Network development, investment levels, regional differences and automation projects.

3. Voltage Quality

3.1 Introduction

The present chapter provides an overview of the existing practice in voltage quality monitoring and regulation on transmission and distribution level in the CPs. Review and analysis of collected voltage quality data shows that **activities towards the introduction of voltage quality monitoring and regulation have started in all CPs**. However, the activities are only in an initial stage and consequently CPs were not able to provide a complete set of data on all voltage quality aspects. The following aspects were analysed:

1. Voltage quality regulation and legislation;
2a. Voltage quality monitoring system (VQMS);
2b. Data collection, aggregation and publication from VQMS;
3. Voltage quality indicators;
4. Actual data for voltage dips, other VQ parameters and mitigation measures; and
5. Studies on estimation of costs due to poor voltage quality.

The information provided by the CPs on these categories is provided in Table 18.

TABLE 18 | Voltage quality information by CPs

CP	Voltage quality regulation and legislation	Voltage quality monitoring system	Data collection, aggregation and publication	VQ indicators	Actual VQ data and mitigation measures	Studies on estimation of costs due to poor VQ
Albania	Yes					
Bosnia and Herzegovina	Yes	Yes	Yes	Yes	Yes	
Croatia	Yes			Yes		
FYR of Macedonia	Yes	Yes	Yes	Yes		
Moldova	Yes			Yes		
Montenegro	Yes			Yes		
Serbia	Yes			Yes		
Ukraine	Yes			Yes		
UNMIK	Yes			Yes		

The table shows that **most of the data is not available yet**. The analysis of this chapter therefore focuses on an overview of the development status of voltage quality monitoring and regulation in the individual CPs.

3.2 Voltage Quality Legislation, Regulation and Standardisation

Data regarding voltage quality implementation via legislation, regulation and standardisation are provided by all the CPs. This implies that CPs have recognised the need for introducing voltage quality requirements in their legal and regulatory framework. Most of the CPs have adopted standard EN 50160 and other VQ and EMC related standards and have created VQ provisions in line with those standards. However, **direct obligations and procedures regarding voltage quality monitoring and regulation are still not clearly defined in the legislation and therefore need to be more directly addressed in the future by adjustments and improvements of legislation and regulation in the CPs.**

3.2.1 Introducing EN 50160

The majority of CPs implemented EN 50160, mainly as a voluntary standard or, also, in legislation and regulation. It is usually defined in the general conditions of supply or network codes, either by a reference to EN 50160 or by directly using the limits required by EN 50160 in legislation or regulation. Consequently, **EN 50160 can be considered as the basic instrument for voltage quality assessment in the CPs.**

EN 50160 is mainly applied on low and medium voltage levels up to 35 kV. In the majority of the CPs where it is implemented, EN 50160 is predominantly used as a standard for supply voltage variations. However, in Croatia limits for other voltage disturbances are also defined more or less in line with EN 50160. In Bosnia and Herzegovina, quality of electricity has to be in line with EN 50160 as of 1 January 2016. In most of the CPs, EN 50160 still has not been translated in practical terms[102].

The implementation status of EN 50160 in each of the reporting CPs is presented in Table 19.

TABLE 19 | EN 50160 Implementation Status

CP	Implementation status	Different standards from EN 510160 and the way they are enforced
Albania	Voluntary standard	Yes, law
Bosnia and Herzegovina	Yes partially, general conditions of supply and grid code; F-BiH: fully from 2016 Republika Srpska: fully from 2015	Yes, law, grid/distribution code
Croatia	Yes partially, general conditions of supply and Grid Code	Yes, grid code
FYR of Macedonia	Voluntary standard, implementation planned for 2012	Yes, law, grid/distribution codes
Moldova	No	Yes, standards committee
Montenegro	No	Yes, grid/distribution codes
Serbia	Voluntary standard; implementation in the grid code planned for 2011	Yes, law, grid/distribution code
Ukraine	No	Yes, standards committee
UNMIK	Yes	Yes, distribution code

3.2.2 Legislations and Regulations that differ from EN 50160

All CPs have introduced voltage quality requirements going beyond EN 50160 in their legislation and regulation. Voltage quality standards that are different from those indicated in EN 50160 are implemented for some voltage characteristics, mainly via laws and network codes as presented in Table 19. In Moldova and Ukraine, voltage quality limits for different voltage characteristics are defined by an interstate standard on voltage quality[103] approved by the *Interstate Council of Standardisation, Metrology and Certification*.

The limits that are defined in legislation and network codes on supply voltage variations mainly correspond to EN 50160 for MV and LV level. In some CPs more strict requirements for supply voltage variations are in place. Voltage limits on other voltage levels mainly ad up to ±5% for 400 kV, ±10% or ±5% for 220 kV and ±10% for 110 kV.

The currently applied voltage quality standards in the CPs are shown in Table 20.

102. EN 50160 has been translated only in three CPs: Bosnia and Herzegovina and Serbia have translated the 2007 version, while only FYR of Macedonia has translated the 2010 version.
103. GOST 13109-97.

TABLE 20 | VQ standards enforced/used on CP level

CP	Supply voltage variation standards	VQ standards for other voltage characteristics
Albania	400 kV: +5%, -10%; 220, 150, 110 kV: ±10%; 35 kV: 31-39 kV; 20 kV: 24 kV (highest voltage); 10 kV: 10,75 kV (highest voltage); 380 V, 220 V: +10%, -15%	No
Bosnia and Herzegovina	Partially EN 50160, IEC 60038 400kV: ±5%; 220kV: ±10% HV, MV: ±10% LV: ±10%(RS), +5%, -10% (F BiH)	Yes, IEC 61000-3-6, IEC 61000-3-7 IEC 61000-3-12, standards
Croatia	400 kV: +5%, -10%; 220 kV: ±10% MV, LV: EN 50160	Yes, mainly in line with EN 50160
FYR of Macedonia	EHV: ±5%; HV, MV: ±10% LV: +5%, -10%	Planned for 2012
Moldova	All voltage levels: ±5%	Yes, GOST 13109-97
Montenegro	400 kV: +5%; 220 kV: ±10%; 110 kV: ±10%; 35 and 10 kV: ±5% LV: ±10%;	No
Serbia	400kV: ±5%; 220kV: 200-240kV HV, MV, LV: ±10%	Planned for 2011
Ukraine	All voltage levels: ±5% (95% of the time) ±10% (marginal voltage variation)	Yes, GOST 13109-97
UNMIK	400 kV: ±5%, (exceptional event ±10%); 220 kV: ±5%, (exceptional event ±10%); 110 kV: ±10%, (exceptional event 88 to 130kV); MV, LV: (35kV, 20kV, 10kV, 6.3kV, 400 V, 230V): +10%; -15%	Yes

3.2.3 Obligations for Monitoring Voltage Quality

Monitoring voltage quality requires monitoring of voltage quality parameters with voltage quality monitoring instruments in a way that provides system-wide evaluation. In some CPs, a direct obligation for system operators to measure voltage quality parameters on a continuous basis or for pre-defined intervals has been introduced by legislation and regulation.

However, in the **majority of CPs detailed procedures and obligations for the establishment of a voltage quality monitoring system have not been defined** in the legal and regulatory framework yet.

Only in FYR of Macedonia, legislation defines detailed procedure and obligations for the implementation of a voltage quality monitoring system, planned for 2012.

FYR of Macedonia

According to the new Energy Law, the Ministry of Economy by means of the *Rulebook on Electricity Quality Control*, shall stipulate the procedure for measuring quality of electricity delivered on DSO and TSO level. Upon proposal of the State Technical Inspectorate, the Minister of Economy shall adopt the plan on electricity quality measurement, including metering points and implementation dynamics for the next calendar year by 31st December the latest. The current *Rulebook on a manner for performing on the quality of electricity in distribution grid*, issued by the Ministry of Economy, defines the responsibility of the State Inspectorate for Technical Inspection to prepare a yearly plan with a monthly dynamic for 10 metering points, covering specific delivery points between TSOs and DSOs and including all categories of customers on distribution network. Metering shall be executed by the State Inspectorate in presence of the DSO within 7 days.

In line with the provisions for implementation of a voltage quality monitoring system, the legal framework in FYR of Macedonia also defines the provisions for collection, aggregation and publication of voltage quality data from the voltage quality monitoring system. According to the legislation, voltage quality data shall be collected and stored by the State Inspectorate for Technical Inspection. By 15th March the latest, the State Inspectorate shall submit to the Ministry of Economy and the RA the report on the implementation of the plan for the previous calendar year. The yearly report shall be published on the website of the State Technical Inspectorate and the Ministry of Economy. Aggregated/ individual voltage quality data shall be made available upon request of the RA and current users.

In the other CPs, no specific requirements regarding voltage quality measuring have been implemented in legislation and regulation, except for Bosnia and Herzegovina where the General Conditions require that measurements of voltage quality have to be executed in accordance with IEC 61000-4 or with the respective standard in Bosnia and Herzegovina (BAS). In some CPs, certain requirements for voltage quality monitoring instruments still exist from the time before the RA became operational.

3.2.4 Individual Voltage Quality Verification

In the majority of CPs, TSO/DSOs are legally obliged to install a voltage quality recorder only upon request of an end-user who experiences problems due to insufficient voltage quality at its connection point. For the other CPs, voltage quality monitoring is performed even if the TSO/DSOs are not legally obliged to do so. In most of the cases, the costs are covered by the TSO/DSO, while in some CPs the costs are charged to the customer in case voltage quality proofs to comply with the requirements. A possibility for an end-user to install its own voltage quality recorder and the measured data in a dispute with the TSO/DSOs is not recognized in the majority of the CPs, with the exception of Ukraine.

Financial penalties for violation of quality limits are only foreseen in Ukraine.

Ukraine

The Electricity Law provides the consumer with the right for compensation in case the DSO does not provide voltage quality in line with the standards. The compensation is calculated as 25% of the cost of electricity consumed during the billing period.

Customers need to address their supplier to conduct a joint measurement of voltage quality parameters and file a claim in which all details (period of time, type of parameters and deviation from standards) have to be indicated[104]. In case the supplier does not meet the relevant customer within the time limits require by the rules[105], the consumer is entitled to file the claim directly and without form requirements. In case the energy supplier refuses to sign the claim, the claim is still considered valid if signed by at least three customers or by the consumer and any RA representative. In case the energy supplier refuses to execute the necessary voltage quality measurements, the customer has the right to organise such measurements by himself. In this case the energy supplier has to reimburse the customer for all related expenses.

Based on the claim the supplier within 10 days has to either take appropriate measures and recalculation of payment for low voltage quality or provide the customer with a reasonable justification for refusal. In case the energy supplier refuses compensation payments, the customer has the right to sue the payment in court.

3.2.5 Individual Information on Voltage Quality

The obligation of providing individual information on voltage quality is still not legally defined in the majority of the CPs. Only in Bosnia and Herzegovina TSO/DSOs are legally obliged to inform the end-user about the past or expected future voltage quality levels. However, it seems that even without legal obligation, TSO/DSOs inform customers about voltage quality levels upon their request.

An overview of the legal obligations covered in Sections 3.2.3, 3.2.4 and 3.2.5 is provided in Table 21.

In most of the CPs, the responsibility for improving the overall voltage quality and/or rectifying voltage disturbances is shared between the State Inspectorate, the TSO/DSOs, customers and the RA. However, responsibilities are not clearly legally defined. The role of the RA is mainly limited to approving codes, while the direct authority for voltage quality regulation is not defined.

104. A template is part of the rules of electricity use for households.
105. 3 days for urban and 7 days for rural areas after receipt of the request.

TABLE 21 | VQ measurement obligations

CP	VQ measurement by the system operator		VQ measurement at end-user's request		TSO/DSO's obligation to inform user on voltage quality
	TSO	DSO	TSO/DSO's recorder	User's recorder	
Albania	Yes, hourly	Yes, hourly	Yes	No	No
Bosnia and Herzegovina	Yes	Yes	Yes	No	Yes
Croatia	No	No	Yes, operator pays if request justified	Yes, not precisely defined	No
FYR of Macedonia	Yes	Yes	Yes, operator pays if request justified	No	No
Moldova	No	Yes, periodically (2 times per year)	Yes, user do not pay	No	No
Montenegro	Yes	Yes	Yes, no pre-defined payment by user	No	No
Serbia	No	No	No	No	No
Ukraine	Yes	No	Yes	Yes	No
UNMIK	No	No	Yes	Yes	Upon user's request

3.2.6 Emission Limits

In order to regulate the impact that customer installations have on the voltage quality of the transmission and distribution network, **the majority of CPs has imposed legislation defining emission limits for individual customer**. Maximal levels of disturbances concerning voltage quality for the end-user installations that are connected to the network are usually defined in the grid and distribution codes[106]. However, **different approaches are identified in defining emission limits**. In the majority of cases, such as Bosnia and Herzegovina, Croatia, Montenegro and UNMIK, emission limits are defined in terms of voltages according to international standards, such as IEC standards and EN 50160. A different approach is used in Serbia, where the maximum levels of electricity emissions are set for the installations connected to the network.

In Croatia, a detailed procedure for emission effects on the system is defined in the Grid Code.

Croatia

User facilities and installations shall be designed and constructed in a way that emissions of the installation's equipment (flicker, asymmetry, higher harmonics etc.) do not exceed the defined values. Prior to the first connection or replacement of a user facility and installation, the possible emission to the system shall be determined in order to proof that the planned values of voltage distortion shall not be exceeded due to the emission effect on the system. In the case of small connection power (Ssc/Scp≥1000 for MV, Ssc/Scp≥150 for LV) or a limited share of non-linear plants and apparatus at a customer, it is possible to consider connection to the system without a detailed evaluation of the impact of the emission on the system. The analysis of the impact of the emission is responsibility of the network user who shall present calculations and proofing to the DSO that his facilities does not exceed the emission limits during a trial run.

Should the emission from a network user cause unacceptable impact, the DSO shall instruct the network user about the way and deadline for restoring the required values or values contracted for. The network user shall decrease the emission within the required values or values contracted for. If the emission from the network user facility and installation produces damage to the equipment of the DSO and other users for a time period exceeding a given deadline, the DSO has the right to temporarily disconnect the network user.

106. Namely in the chapters dealing with connection to the transmission and distribution network.

Penalties for customers in case of violation of the maximum levels of disturbances - other than disconnection - are not envisaged in any of the observed CPs.

3.3 Voltage Quality Monitoring Systems and Data

A voltage quality monitoring system has been implemented only in Bosnia and Herzegovina and consequently actual voltage quality data has been provided by Bosnia and Herzegovina only. The other CPs still have not installed voltage quality monitoring system.

3.3.1 Development of Voltage Quality Monitoring Systems

Bosnia and Herzegovina has voluntarily implemented a voltage quality monitoring system for the purpose of statistics and research. Voltage quality monitoring is mainly executed on HV/MV delivery points between the TSO and the DSO with portable instruments, namely with one instrument per location and type of network points monitored, on a rolling basis. Pre-defined tariffs exist for the cost of monitoring.

3.3.2 Smart Meters and Voltage Quality Monitoring

In most of the CPs smart meters have not been introduced for the time being. However, in some CPs a small number of smart meters have been already installed. However, those meters do not allow for voltage quality monitoring and there are no related functionality requirements for smart meters imposed.

3.3.3 Data Collection, Aggregation and Publication from Voltage Quality Monitoring System

Taking into account that most of the surveyed CPs still do not have any voltage quality monitoring system implemented, they also do not have any practice and procedures established for data collection, aggregation and publication.

Consequently, only Bosnia and Herzegovina provided information on current practice in collection, aggregation and publication of voltage quality data from the voltage quality monitoring system. Collected data is stored centrally and available upon request of the RA and network users. This data has been published only in studies, since responsibility for publication has not been defined yet.

3.3.4 Actual Data for Voltage Dips, other VQ Parameters and Mitigation Measures

Almost no CP was able to provide any actual data on voltage dips and other VQ parameters. Also, data on mitigation measures is not available.

Only Bosnia and Herzegovina provided some monitoring data on VQ parameters, reporting a value of 132 voltage dips per HV substation delivery points per year (estimated) based on 33 voltage dips registered in the measurement campaign at a limited number of locations (6) during part of 2008 (91 day). Data for the following years were not available. In the period 27 March, to 2 May 2010 high voltages were recorded in 400 kV and 220 kV network in Bosnia and Herzegovina where practically in all nodes at 400 kV and in some nodes at 220 kV, voltages exceeded the upper limits up to 32% of the total measuring time. In order to resolve VQ problems in the network, study has been done and non-allowed voltages were identified.

3.4 Findings and Recommendations on Voltage Quality

Finding #1
EN 50160 is implemented in most CPs

EN 50160 is implemented in most CPs, mainly as voluntary standard but also by legislation and regulation. It is usually defined in the general conditions of supply or network codes, either by reference to the EN 50160 or by taking its limits over. EN 50160 is mainly applied on low and medium voltage levels up to 35 kV. Additionally, it is predominantly used as standard for supply voltage variations.

In most of the CPs, EN 50160 has not been translated.

Voltage quality standards that differ from EN 50160, such as IEC 61000-x-x have been introduced for some voltage characteristics, mainly via national legislation and network codes. Different standards are introduced for different reasons: historical, different network characteristics, introducing new stricter limits, etc.

Recommendation #1

Introduction of EN 50160 and IEC 61000-x-x in CP standardization, legislation and regulation

CPs that have not adopted EN 50160 are encouraged to do so. Those CPs that already adopted but have not translated EN 50160 should make the effort to translate EN 50160 with a view to have precise definitions in national language and to allow further development of terminology. This also applies to other widespread standards like IEC 61000-x-x.

Implementing provisions in legislation (i.e. grid codes or voltage quality rules) that are consistent or stricter than EN 50160 and IEC 61000-x-x is recommended. Those CPs that have done so already should further improve the precision of definitions, limitations and exceptions. Since most CPs so far focused on supply voltage variations, efforts should be extended to encompass all voltage characteristics mentioned in EN 50160. Deviations from EN 50160, IEC 61000-x-x and other standards should be avoided as much as possible keeping in mind CP specifics.

These recommendations are preconditions for the RAs to make efficient decisions on voltage quality regulation.

Finding #2

Legislation and regulation do not address voltage quality monitoring

Detailed procedures and obligations for the establishment of a voltage quality monitoring system have not been defined in the legal and regulatory frameworks of most CPs. FYR of Macedonia is the only CP where legislation defines detailed procedures and obligations for implementing a voltage quality monitoring system.

Recommendation #2

Introduction of voltage quality monitoring obligations

Direct obligations as well as detailed procedures for the establishment of a voltage quality monitoring system **should be defined in legislation and regulation in all CPs**. Provisions regarding requirements for voltage quality instruments, collection, aggregation and publication of voltage quality data from the voltage quality monitoring system should be established too.

Finding #3
Voltage quality monitoring systems have not been implemented

Voltage quality monitoring systems for continuous voltage quality monitoring have not been installed in any of the CPs. Data on actual voltage quality levels therefore is not available. Only in Bosnia and Herzegovina, a voltage quality monitoring system for the purpose of research has been voluntarily installed, and consequently some data has been provided.

Recommendation #3

Voltage quality monitoring systems should be implemented

CPs should courage TSO/DSOs to develop voltage quality monitoring systems for continuous voltage quality monitoring in their networks. Monitoring should take place at locations at which a good estimation of the voltage quality as experienced by customers can be made. It is further acknowledged that the data from continuous voltage quality monitoring can provide useful information for the TSO/DSOs, resulting in significant cost savings and information to support investment decisions.

Having in mind that implementation of voltage quality monitoring systems have not started yet in the CPs, it is recommended for the CPs - prior to the implementation - to undertake joint activities towards **harmonisation of voltage quality parameters and measurement methods**.

The key scope of compulsory or regulator-controlled monitoring should be to verify compliance with voltage quality requirements (both overall and for individual customers); to provide information to customers on their actual or expected voltage quality; and to obtain information for the setting of appropriate future requirements. This should be considered when deciding about the need for compulsory or regulator-controlled monitoring.

Finding #4
Individual voltage quality verification is available in the majority of the CPs

In most CPs, TSO/DSOs are legally obliged to provide individual voltage quality verification upon request of end-users who experiences voltage quality problems. In several CPs, even without a legal obligation, in practice, TSO/DSOs perform individual voltage quality verification. In most of the cases, costs are covered by the TSO/DSO, while in some CPs costs are covered by the customer in case that voltage quality proofs to comply with the requirements. The obligation of providing individual information on voltage quality is still not legally defined in the majority of the CPs.

Recommendation #4

Introduction and development of individual voltage quality verification provisions

The legal obligation for TSO/DSOs to provide individual voltage quality verification upon user's request **should be adopted in all CPs**. This obligation should be accompanied by a detailed description of the procedure by the TSO/DSOs ensuring that all relevant information about the procedure is available to customers, including the definition and allocation of costs related to the verification.

Statistics on complaints and verification results should be used by system operators for identifying areas that need improvements. RAs should use such statistics for regulatory decisions regarding voltage quality.

It is further recommended that statistics on complaints and verification results correlate with the results from continuous voltage quality monitoring (if in place).

In the verification process, the system operator should make reasonable efforts to identify the cause of the disturbance.

Finding #5
Emission levels of network users

In most CPs, legislation defining emission limits by individual network users has been imposed. Emission limits are usually defined by grid and distribution codes[107]. Different approaches are identified in defining emission limits. In most CPs, emission limits are defined in terms of voltages according to international standards, such as IEC standards and EN 50160, except for Serbia where maximum levels of electricity current emissions are set.

Penalties for customers in the case of violation of emission limits - other than disconnection - are not envisaged in any of the CPs.

Recommendation #5

Provisions regarding emission levels should be developed

Emission limits from individual customers are necessary to maintain the voltage disturbance levels within the voltage quality requirements without excessive costs for other customers. The limits on emission should be reasonable for both the TSO/DSOs and the customers causing the emission.

Introduction of emission limits for individual network users by legislation or regulation should go hand in hand with the legal establishment of voltage quality standards that TSO and DSOs have to comply with.

In case of violations of emission limits by a network user, mitigation measures should be coordinated by the TSO and DSOs.

A network user should pay penalties or be obliged to carry out corrective measure if user's installation is the source for a voltage complaint.

107. Namely in the chapters dealing with connection to the transmission and distribution network.

4.Commercial Quality

4.1 Introduction

The present benchmarking activity is the first major effort to systematically investigate Commercial Quality (CQ) in the CPs. The answers received indicate that regulation of Commercial Quality still is in an early stage in all assessed CPs.

The questionnaire used for the present report stressed the complexity of Commercial Quality with multiple suppliers and regulated entities like DSO and Universal Service Providers. A brief examination of a supposedly simple business process, like solving a Voltage Quality complaint, reveals that CQ standards strongly correlate with the market design and legal framework. For **most CPs this implies the need to further develop the legislation and practice to accommodate even basic service quality regulation.** For example, on the process of solving a Voltage Complaint, precise definitions of triggers and time intervals are crucial, as well as defining the entity on which a certain trigger/event/process applies to, since it is really different if the customer calls his supplier in comparison to the scenario where the customer calls to DSO directly.

4.2 Overview of Commercial Quality Standards in CPs

As suggested by the previous CEER Benchmarking reports and the questionnaire used for the present benchmarking, CQ requirements have been categorised in two main: Guaranteed Standards (GSs) and Overall Standards (OSs) and two supplementary: Other Available Requirements (OAR) and Only Monitoring (OM) standards. The explanation of the standards can be found in Section 4.4.3 of Chapter 4 (Commercial quality chapter) of this Benchmarking Report.

Commercial quality has been reviewed by using the same four groups of indicators applied in Section 4.4.1 of Chapter 4 (Commercial quality chapter) of this Benchmarking Report:

1. Connection (Group I);
2. Customer Care (Group II);
3. Technical Service (Group III); and
4. Metering and billing (Group IV).

The assessment shows an overwhelming use of explicit provisions regarding quality where the standard is applied to all (100%) cases (Table 22). Although such provisions are in essence GS, in line with the benchmarking guidelines, such standards are labeled as OAR because there is no compensation for individual customers and often there is no penalty defined. For most of these standards, penalties are based either on vague and imprecise general penal provisions or simply do not exists (even if required by primary legislation). Additionally, it should be mentioned that the OARs present in the Energy Community CPs are usually not influenced by the RA, but are rather defined in primary or secondary legislation.

Table 22 shows that commercial quality is largely enforced by OAR (91 out of a total of 116). All analysed CPs approximately have the same number of standards - in the range of [9, 16] - with the exception of Albania that reported just 3 standards. Higher values for Serbia and UNMIK are a result of multiple standards set within an indicator (i.e. Serbia usually has different standards for LV and MV).

Table 23 shows that there is no particular group with a prevailing number of standards. This means that **CQ is equally developed** (or rather equally undeveloped) **in all indicator groups, with the exception of group II** – Customer Care which has twice as many indicators in comparison to other groups.

If the total number of standards per indicator is considered (again Table 23), it shows that indicator "I.3 Time for connecting new customers to the network" has the highest number of standards. Closely following are indicators dealing with connections claims and disconnections (I.3, I.4 and IV.16). Also, handling complaints is important with a high total of standards (II.6, II.6a).

For the present benchmarking the distinction between standards applied to DSOs, Suppliers and Universal Suppliers (USPs) is presently not informative since national electricity markets are developing. Therefore, an overview of standards and data availability with respect to the relevant company is skipped. However, some remarks will be given in the chapters analysing particular groups of indicators.

It should be noted that the current benchmarking is mainly focused on commercial performances of

DSOs and less on performances in the competitive sector of supply.

The analysis also proofed that no adequate statistical data exists for most CQ indicators.

TABLE 22 | Number of Commercial Quality Standards for each CP

CP	Guaranteed standards (GS)	Overall standards (OS)	Other available requirements (OAR)	Only Measuring (O/M)	Total
Albania	0	3	0	0	3
Bosnia and Herzegovina	0	0	13	3	16
Croatia	0	0	9	0	9
FYR of Macedonia	0	0	13	0	13
Moldova	2	3	7	0	12
Montenegro	0	0	10	0	10
Serbia	0	0	15	6	21
Ukraine	0	0	13	0	13
UNMIK	0	8	11	0	19
TOTAL	**2**	**14**	**91**	**9**	**116**

TABLE 23 | Number of Commercial Quality Standards for each indicator

Standards	GS	OS	OAR	O/M	Total
I. CONNECTION					
I.1 Time for response to customer claim for network connection		2	8		10
I.2 Time for cost estimation for simple works		1	3		4
I.3 Time for connecting new customers to the network		4	7		11
I.4 Time for disconnection upon customer's request			7	1	8
TOTAL FOR CONNECTION INDICATORS	0	7	25	1	33
II. CUSTOMER CARE					
II.5 Punctuality of appointments with customers			1		1
II.6 Response time to customer complaints and enquiries (including 6a and 6b)			7	2	9
II.6a Time for answering the voltage complaint		1	6	2	9
II.6b Time for answering the interruption complaint			3	2	5
II.7 Response time to questions in relation with costs and payments (excluding connection)			5		5
II.8 Call Centres average holding time					0
II.9 Call Centres service level					0
II.10 Waiting time in case of personal visit at customer centres					0
TOTAL FOR CUSTOMER CARE INDICATORS	0	1	22	6	29
III. TECHNICAL SERVICE					
III.11 Time between the date of the answer to the VQ complaint and the elimination of the problem	1	1	4		6
III.12 Time until the start of restoration of supply following failure of fuse of DSO		4	1	1	6
III.13 Time for giving information in advance of a planned interruption		2	5		7
III.14 Time until the restoration of supply in case of unplanned interruption	1		3	1	5
TOTAL FOR TECHNICAL SERVICE INDICATORS	2	7	13	2	24
IV. METERING AND BILLING					
IV.15 Time for meter inspection in case of meter failure			6		6
IV.16 Time from the notice to pay until disconnection			9		9
IV.17 Time for restoration of power supply following disconnection due to non-payment			7		7
IV.18 Yearly number of meter readings by the designated company			8		8
TOTAL FOR METERING AND BILLING INDICATORS	0	0	30	0	30
TOTAL	**2**	**15**	**90**	**9**	**116**

4.3 Main Results of Benchmarking Commercial Quality Standards

4.3.1 Group I – Connection

Most electricity legal frameworks encompass commercial standards regarding connections. CPs have similar standards and approaches to monitoring connection issues. This of course accounts for predominant use of OAR standards as explained earlier.

Connection-related activities have a complex structure. Nevertheless, the four quality indicators (as presented in Table 24) defined in the benchmarking questionnaire represent the whole process for connection. The questionnaire put emphasis on the division between LV and MV customers (requesting information on voltage levels that a standard applies to). However, CPs rather differentiate connection procedures based on the type of customer instead. In addition to the obvious household type, categorizations used in different CPs distinguish between legal entities, commercial customers on different voltage levels, etc. Connection procedures revolve around those types and "simple works" do not rely on common criteria.

Due to the current levels of market opening, standards for connection related activities in CPs apply to the DSO.

TABLE 24 | Commercial Quality standards for connection-related activities

Quality Indicator	CPs (grouped by type of standard)	Standards (median value and range)	Compensation (median value, GS only)	Company involved
Time for response to customer claim for network connection	**OS:** Albania, Moldova **OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Montenegro, Serbia, Ukraine, UNMIK	25 days (15 - 30 days)	-	DSO
Time for cost estimation for simple works	**OS:** Albania **OAR:** Bosnia and Herzegovina, FYR of Macedonia, UNMIK **None:** Croatia, Moldova, Montenegro, Serbia, Ukraine	21 days (8 - 30 days)	-	DSO
Time for connecting new customers to the network	**OS:** Albania, UNMIK **OAR:** FYR of Macedonia, Croatia, Montenegro, Moldova, Serbia, Ukraine **None:** FYR of Macedonia	20 days (4 - 45 days)	-	DSO
Time for disconnection upon customer's request	**OAR:** FYR of Macedonia, Moldova, Montenegro, Serbia, Ukraine, UNMIK **O/M:** Bosnia and Herzegovina **None:** Albania, Croatia	12 days (3 - 30 days)	-	DSO

4.3.2 Group II – Customer Care

Customer Care is the group of indicators with the lowest number of standards. For certain indicators, none of the CPs have adopted standards. Of course, it can be argued that this is a direct reflection of the low level of competition. Another reason can be that the liberalisation of national energy sectors is lagging behind, compared to EU countries.

Direct interaction with customers is not monitored – starting with the lack of call centres (used by DSOs and incumbent suppliers), appointments and visits are not planned/recorded, etc. (as shown in Table 25).

Another aspect is that DSOs and incumbent companies have not focused on customers and many customer care indicators encountered in this benchmarking were purely statistical information on certain commercial activities. For example, customer complaints are recorded and average times can be calculated (or more often estimated). However, as a rule, **DSOs and incumbent companies do not have customer relationship management or any similar system**, so there is no possibility to track a specific customer with a specific issue. Therefore data on indicators related to customer care as defined in the benchmarking questionnaire is not available.

TABLE 25 | Commercial quality standards for customer care activities

Quality Indicator	CPs (grouped by type of standard)	Standards (median value and range)	Compensation (median value, GS only)	Company involved
Punctuality of appointments with customers	**OAR:** Bosnia and Herzegovina **None:** Albania, Croatia, FYR of Macedonia, Montenegro, Serbia, Ukraine , UNMIK	-	-	DSO
Response time to customer complaints and enquiries (total, including voltage complaints and interruption complaint)	**OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Moldova, Montenegro, Ukraine, UNMIK **O/M:** Serbia **None:** Albania	26 days (15 - 30 days)	-	DSO
Time for answering the voltage complaintas part of response time to customer complaints and enquiries)	**OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Moldova, Montenegro, Ukraine, UNMIK **O/M:** Serbia **None:** Albania	16 days (2 - 30 days)	-	DSO
Time for answering the interruption complaint as part of response time to customer complaints and enquiries	**O/M:** Serbia **OAR:** FYR of Macedonia, Montenegro, UNMIK **None:** Albania, Bosnia and Herzegovina, Croatia, Moldova, Ukraine	20 days (15 - 30 days)	-	DSO
Response time to questions in relation with costs and payments (excluding connection)	**OAR:** Bosnia and Herzegovina, Croatia, Montenegro, Ukraine, UNMIK **None:** Albania, FYR of Macedonia, Moldova, Serbia	8 days (1h - 8 days)	-	DSO
Call centres average holding time	-	-	-	-
Waiting time in case of personal visit at customer centres	-	-	-	-

Table 25 clearly shows that all CPs lack call centre standards and do not record visits/appointments. This information has been included in the table on purpose with a view to emphasize the need for developing technical systems designed for customer care.

4.3.3. Group III –Technical Service

This particular group of quality indicators is the most diverse group within Commercial Quality. This is reasoned by the fact that different CP use different approaches for CQ regulation and are at different development stages. This is not evident from the benchmarking data presented in this report but was observed in the answers and remarks given by the CPs.

Standards related to technical services in principle correspond to standards during the contract period and are tied to technical services of the DSO. All CPs identified the DSO as company involved. Nevertheless, it was observed that standards for technical services (and the legal framework governing the supplier business) must be developed to accommodate scenarios where customers contact the DSO directly or their supplier for technical services.

It is worth mentioning that Moldova has the most developed standards in the group of Technical Services, including OSs and GSs with compensation (the only GS in the benchmarking), Table 26.

TABLE 26 | The commercial standards for technical services in Moldova

Standard	Type of requirement	Quantity	Unit	% of cases	Compensation / Penalty	Remark
Time between the date of the answer to the VQ complaint and the elimination of the problem	GS	60	days	100%	25% from the bill for electricity, consumed in the period.	The problem must be eliminated in 24 hours, 15, 30 or 60 days, depending on the works needed.
Time until the start of restoration of supply following failure of fuse of DSO	OS	1	hours	90%	0,5% tariff reduction.	Standard for the TSO.
Time for giving information in advance of a planned interruption	OS	3-7	days	90%	0,1% tariff reduction.	3 days for small customers and 7 for big customers.
Time until the restoration of supply in case of unplanned interruption	GS	24	hours	100%	2, 15 or 30 € for every hour, depending on the contracted power.	Restoration must be completed in 6, 16 or 24 hours, depending on the cause and severity of accident.

TABLE 27 | Commercial quality standards for technical services

Quality Indicator	CPs (grouped by type of standard)	Standards (median value and range)	Compensation (median value, GS only)	Company involved
Time between the date of the answer to the VQ complaint and the elimination of the problem	**GS:** Moldova **OS:** UNMIK **OAR:** Bosnia and Herzegovina, Serbia, Ukraine **None:** Albania, Croatia, FYR of Macedonia, Montenegro	25 days (1 - 60 days)	-	DSO
Time until the start of restoration of supply following failure of fuse of DSO	**OS:** Moldova, UNMIK **OAR:** FYR of Macedonia **O/M:** Bosnia and Herzegovina **None:** Albania, Croatia, Montenegro, Serbia, Ukraine	12 hours (1 - 24 hours)	-	DSO
Time for giving information in advance of a planned interruption	**OS:** UNMIK, Moldova **OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Serbia, Ukraine **None:** Albania, Montenegro	3 days (1 - 10 days)	-	DSO
Time until the restoration of supply in case of unplanned interruption	**GS:** Moldova **O/M:** Bosnia and Herzegovina **OAR:** FYR of Macedonia, Serbia, Ukraine **None:** Albania, Croatia, Montenegro, UNMIK	18 hours (2- 24 hours)	-	DSO

4.3.4 Group IV – Billing and Metering

Billing and metering is the **only group of quality indicators where CPs reported standards that apply to companies other than the DSO**. This is not surprising, since the development of markets starts with payments and measurements, in this case electricity metering.

Although the indicators in this group - as shown in the first column of Table 28 - are instantly recognizable, the **actual standards and ranges used by different CPs show that billing and metering should be developed in terms of definitions** needed for precisely defining standards. For example, the indicator “time from the notice to pay until disconnection” may be understood as “time from sending the notice…” or “time from when the notice is received…”.

Similar to the group "Technical Services", standards within "Billing and Metering" depend on whether or not customers must rely on a supplier for billing and metering or can directly communicate or carry out business with the DSO or the metering company.

TABLE 28 | Commercial Quality Standards for billing and metering

Quality Indicator	CPs (grouped by type of standard)	Standards (median value and range)	Compensation (median value, GS only)	Company involved
Time for meter inspection in case of meter failure	**OAR:** Bosnia and Herzegovina, FYR of Macedonia, Serbia, Ukraine, UNMIK **None:** Albania, Croatia, Moldova, Montenegro	14 days (2 - 30 days)	-	DSO, MO
Time from the notice to pay until disconnection	**OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Moldova, Montenegro, Serbia, Ukraine, UNMIK **None:** Albania	13 days (3 - 30 days)	-	DSO
Time for restoration of power supply following disconnection due to non-payment	**OAR:** Bosnia and Herzegovina, FYR of Macedonia, Moldova, Montenegro, Serbia, Ukraine, UNMIK **None:** Albania, Croatia	2 days (1 - 7 days)	-	DSO, SP
Yearly number of meter readings by the designated company	**OAR:** Bosnia and Herzegovina, Croatia, FYR of Macedonia, Moldova, Montenegro, Serbia, Ukraine, UNMIK **None:** Albania	8 Meter Readings per Year (2 - 12)	-	DSO, SP, USP, MO

4.4 Findings and Recommendations on Commercial Quality

In general, commercial quality is in an early stage in all surveyed CPs. Therefore, all general recommendations for developing quality of service can apply. However, there are four issues that are specific the CPs should be recognised.

It should also be mentioned that **Commercial Quality in the CPs should be considered in a broader perspective. Customer rights are definitely lagging behind in comparison to customer rights in the EU**.

Finding #1

There is an overwhelming use of standards that apply to all customers

There is an overwhelming use of explicit provisions that apply to all (100%) customers (cases). These provisions are in essence GS but they do not entail compensation for individual customers or a penalty for the company.

Recommendation #1

Existing standards that apply to all customers should be more specific

At first sight, it would not be difficult to develop such OARs into GS. It would be a simple matter of defining compensation for individual customers.

However, that approach would be risky since quality standards should be introduced gradually – initially starting with measuring performance. Applying a GS without a proper quantitative analysis can affect companies financially much more than expected or initiate a tremendous number of complaints that must be handled (by the utility or the RA).

Therefore, starting from the existing standards, new ones should be created based on the following approach:

- Exemptions should be possible, allowing some flexibility until a proper percentage of cases can be defined within a GS;
- Definitions should be developed in order to allow monitoring and acquisition of data; proper regulatory decisions or standards can be adopted only based on statistical data; and
- For those standards or regulatory provisions that lack compensation for customers or penalties for companies, the most appropriate penance should be found. In other words, an investigation should be made regarding compensation *vs.* penalty or GS *vs.* OS (or even a combination) to accommodate practice and regulatory schemes.

Of course, OAR standards are not predetermined to be supplemented by a GS. With a gradual approach for creating standards, an OAR can be transformed into one or more different standards of different type. The process can also maintain the original OAR standard if necessary.

The 4th CEER Benchmarking Report on Quality of Electricity Supply showed that countries in the Central East of Europe (CEE) predominantly use guaranteed standards. Due to similarities between CEE countries and CPs, it may be worthwhile to investigate their experiences in CQ.

Finding #2
CQ standards are not specifically applied to suppliers or operators

Commercial Quality Standards may be applied to different market participants and operators. As the benchmarking questionnaire suggests, standards can apply to DSOs, Suppliers, USPs and others.

Currently, the distinction between standards applied to DSOs, Suppliers and USPs is not informative for the CPs since electricity markets are developing.

Recommendation #2

CQ standards should be created having in mind different entities (DSOs, Suppliers, USPs, etc.) and different market models

The existence of different entities (DSOs, Suppliers, USPs, etc.) requires that standards should be defined with very specific definitions and with specific business processes in mind. For example, CQ standards related to interruptions can be different depending of the (retail) market model. In one market, customers could be compelled to call their supplier for power restoration with no direct contact with the DSO. In another market, customers could have the choice to call either their supplier or the DSO. Consequently, the category "time until the restoration of supply in case of unplanned interruption" is not universally applicable and may distort benchmarking results.

This also implies that RAs should have deep insight rights in the procedures of suppliers. It may be argued that CQ standards should be tied to regulated activities (DSO/USP/ regulated Supplier). However, using CQ standards for all market players may be beneficial in a couple of ways:

- required publication of CQ performance can be used as a tool for making the market more active by forcing the suppliers to differentiate by CQ performance;
- with new market entrants, some customer groups could be troubled (i.e. residential customers switching to new suppliers) by dominant incumbent electricity companies, so CQ standards are necessary to resolve certain problems;
- poor performance of a supplier may indicate to the RA a more serious issue afflicting the supplier.

It should be emphasized that Directive 2009/72/EC calls for regulation of CQ, particularly with Article 3 dealing with "public service obligations and customer protection".

Finding #3
CQ standards are usually loosely defined

During the benchmarking, it was observed that many CQ indicators were rather obvious (according to the wording), but only superficially defined. Minor differences in legal provisions or practice between CPs showed that standards need to be defined on precise terms and supported with explanations and exceptions.

The indicator "time from the notice to pay until disconnection" can be used here to clarify. The standard should precisely define the initial trigger and define the closing event. Otherwise, there could be questions like – does this standard imply time counted from the post of notice or from the reception of the notice?

Recommendation #3

CQ standards should be based on specific and precise definitions

This issue does not need a specific solution since the recommendation is rather obvious. However, RAs and DSOs should cooperate by sharing experiences or participating in benchmarks. By doing so, the development of definitions and standards will be more efficient and rapid.

Of course, practice of EU member states should also be considered.

Since most CPs did not provide historic data, it would be beneficial to commence with measuring performance in any way possible. The framework for measuring performance will gradually evolve, producing basis for introducing adequate definitions and standards.

Finding #4
DSOs and incumbent companies do not place emphasis on interaction with customers

DSOs and incumbent companies have not focused on customers but predominantly on their own activities. Most of their statistical data that can correlate with commercial standards is related to the "system". Historically, there was no need to track a specific customer with a specific issue. Consequently, data regarding commercial quality, especially to customer care, is not available.

Recommendation #4

DSOs and suppliers should implement Customer Relationship Management (CRM)

DSOs and suppliers should implement IT solutions for CRM. Apart from inherently adopting customer care, the use of such tools is essential for CQ standards.

The most important paradigm for companies is to implement the ability of tracking a specific customer with a specific issue. Apart from having better and more efficient relations with specific customers, statistics on an issue (time, cases, etc.) are statistics relevant for CQ standards related to Customer Care.

Appendix A – Annex to Chapter "Quality of Supply"

TABLE 29 | The relative change in network characteristics and other structural data

SYSTEM DATA	Bosnia and Herzegovina	Croatia	FYR of Macedonia	Moldova	Serbia	Ukraine	UNMIK
	Relative change - 2010/2006 [%]						
Item # 1 - Length of networks							
Total length of circuits - EHV network	-12,28	8,57	14,51		1,24	0,57	0,12
Total length of circuits - HV network	6,11	4,76	0,13		1,07	8,32	10,82
Length of cable circuits - MV network	19,40	15,02			18,99	7,70	
Total length of circuits - MV network	3,63	5,49	3,92		12,09	-1,50	
Length of cable circuits - LV network	18,96	13,84			16,43	10,68	
Total length of circuits - LV network	9,92	3,92	3,21		14,95	-2,70	
Item # 2 - Energy							
Transmitted/distributed energy (all customers)	5,88	3,82	-6,30	6,54	3,93	-2,73	25,22
Distributed energy (only MV and LV customers)	14,59	5,16	10,59	11,37	4,31	-3,54	
Item # 3 - Customers							
Number of MV connection points of final customers	20,16	4,23	-3,96		8,39	6,33	
Number of LV connection points of final customers	7,89	5,18	8,13		4,78	1,07	
Item # 4 - Equipment							
Number of MV feeders starting from HV/MV or EHV/MV transf. stations	1,93	26,70					
Number of MV feeders equipped with remote control (SCADA)		26,70					
Item # 5 - General info							
Number of DSOs	0,00	0,00	0,00	0,00	0,00	4,55	0,00
Customers served by the largest DSOs	7,56	5,18	8,11	4,52	3,69	3,94	
Customers served by the three largest DSOs	6,25	5,18	8,11	3,92	5,36	0,51	

TABLE 30 | The rate of underground circuits per voltage level

CP	MV, 2010				LV, 2010			
	Length of underground MV circuits, km	Length of overhead MV circuits, km	Total length of MV circuits, km	Rate of underground circuit on MV network	Length of underground LV circuits, km	Length of overhead LV circuits, km	Total length of LV circuits, km	Rate of underground circuit on LV network
Bosnia and Herzegovina	4329,00	20515,00	24844,00	17,42	4953,00	61316,00	66269,00	7,47
Croatia	14766,00	25670,30	40436,30	36,52	26535,00	67140,20	93675,20	28,33
FYR of Macedonia	2983,50	8384,98	11368,48	26,24	3279,00	11320,00	14599,00	22,46
Moldova	2139,21	21358,59	23497,80	9,10	1822,50	30426,57	32249,06	5,65
Serbia	11039,00	38236,00	49275,00	22,40	11983,00	95089,00	107072,00	11,19
Ukraine	52772,00	384502,00	437274,00	12,07	40611,00	446884,00	487495,00	8,33
UNMIK	1013,62	6150,05	7163,67	14,15	485,98	11503,78	11989,76	4,05
Average				**19,88**				**12,38**

TABLE 31 | The rate of underground circuits per voltage level and SAIDI

CP, 2010	Rate of underground circuit on MV network	Rate of underground circuit on LV network	Unplanned interruptions (all events), SAIDI [min/cust.] - 2010	Unplanned interruptions (all events), SAIFI [interr./cust.] - 2010
Bosnia and Herzegovina	17,42	7,47	877,17	11,99
Croatia	36,52	28,33	288,86	2,79
FYR of Macedonia	26,24	22,46		
Moldova	9,10	5,65	570,00	5,32
Serbia	22,40	11,19	907,00	9,00
Ukraine	12,07	8,33	657,30	4,27
UNMIK	14,15	4,05	5739,00	38,83

TABLE 32 | Unplanned SAIDI, all interruptions, all events

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			742,87	661,66	877,17
Croatia - HV, MV, LV	632,00	346,81	304,40	261,33	288,86
Moldova - MV		1205,00	838,00	581,00	570,00
Serbia - EHV, HV, MV, LV				772,00	907,00
Ukraine - EHV, HV, MV, LV				762,80	657,30
UNMIK - EHV, HV, MV, LV					5739,00

TABLE 33 | Unplanned SAIFI, all interruptions, all events

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			10,04	11,85	11,99
Croatia - HV, MV, LV	3,97	3,73	3,02	2,99	2,79
Moldova - MV		8,71	6,76	5,15	5,32
Serbia - EHV, HV, MV, LV				10,00	9,00
Ukraine - EHV, HV, MV, LV				3,83	4,27
UNMIK - EHV, HV, MV, LV					38,83

TABLE 34 | Planned SAIDI, all interruptions, all events

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			533,78	810,02	847,61
Croatia - HV, MV, LV	472,14	334,16	291,63	264,60	275,63
Serbia - EHV, HV, MV, LV				349,00	441,00
Ukraine - EHV, HV, MV, LV				534,85	544,60

TABLE 35 | Planned SAIFI, all interruptions, all events

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			7,08	6,16	6,18
Croatia - HV, MV, LV	2,79	2,37	2,07	1,85	1,99
Serbia - EHV, HV, MV, LV				2,00	2,40
Ukraine - EHV, HV, MV, LV				2,46	2,69

TABLE 36 | Planned SAIDI/Total SAIDI

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			41,81	55,04	49,14
Croatia - HV, MV, LV	42,76	49,07	48,93	50,31	48,83
Serbia - EHV, HV, MV, LV				31,13	32,72
Ukraine - EHV, HV, MV, LV				41,22	45,31

TABLE 37 | Planned SAIFI/Total SAIFI

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - EHV, HV, MV			41,36	34,20	34,01
Croatia - HV, MV, LV	41,27	38,85	40,67	38,22	41,63
Serbia - EHV, HV, MV, LV				16,67	21,05
Ukraine - EHV, HV, MV, LV				39,11	38,65

TABLE 38 | AIT (Transmission)

CP	2006	2007	2008	2009	2010
Croatia		18,8	19,5	54,6	25,4
Serbia				32,89	24,73
UNMIK[108]		714,00	690,00	771,00	230,00

TABLE 39 | ENS (Transmission)

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina			4518,26	3823,09	3383,07
Croatia		630,00	666,00	1840,00	867,00
Serbia				2508,56	1549,00
UNMIK[109]		11470,00	11166,00	11462,00	3803,00

TABLE 40 | UNPLANNED SAIDI (all events, distribution) - The distribution of incidents according to their voltage level [minutes per customer]

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina (Republika Srpska only) - LV			40,38	54,62	28,14
Bosnia and Herzegovina (Republika Srpska only) - MV			474,47	390,64	457,26
Bosnia and Herzegovina (Republika Srpska only) - HV			15,88	-5,75	18,71
Bosnia and Herzegovina (Republika Srpska only) - All networks			530,73	439,51	504,11
Croatia - LV	21,09	36,69	15,67	14,20	16,51
Croatia - MV	413,89	167,97	177,54	162,15	145,68
Croatia - HV	14,01	15,79	9,44	11,05	8,75
Croatia - All networks	448,99	220,45	202,65	187,40	170,94
Ukraine - LV				77,13	64,80
Ukraine - MV				425,27	395,70
Ukraine - HV				1,75	4,10
Ukraine - All networks				504,15	464,60

TABLE 41 | UNPLANNED SAIFI (all events, distribution) The distribution of incidents according to their voltage level [minutes per customer]

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina (Republika Srpska only) - LV			0,26	0,24	0,15
Bosnia and Herzegovina (Republika Srpska only) - MV			7,31	6,03	7,93
Bosnia and Herzegovina (Republika Srpska only) - HV			0,27	0,57	0,15
Bosnia and Herzegovina (Republika Srpska only) - All networks			7,84	6,85	8,23
Croatia - LV	0,16	0,19	0,14	0,12	0,13
Croatia - MV	2,21	2,06	1,57	1,77	1,60
Croatia - HV	0,56	0,45	0,46	0,35	0,27
Croatia - All networks	2,93	2,70	2,17	2,24	2,00
Ukraine - LV				0,41	0,44
Ukraine - MV				2,45	2,81
Ukraine - HV				0,03	0,06
Ukraine - All networks				2,89	3,31

108. The data for the 2007, 2008 and 2009 was roughly estimated (shall not be considered in comparison).
109. The data for the 2007, 2008 and 2009 was roughly estimated (shall not be considered in comparison).

TABLE 42 | UNPLANNED SAIDI (all events) - Contribution of MV to aggregated value

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - MV				**544,96**	**471,49**
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				116,70	405,68
Bosnia and Herzegovina - Aggregated				661,66	877,17
Croatia - MV	**413,89**	**167,97**	**177,54**	**162,15**	**145,68**
Croatia - Other (LV, HV, EHV, exceptional events)	218,11	178,84	126,86	99,18	143,18
Croatia - Aggregated	632,00	346,81	304,40	261,33	288,86
Ukraine - MV				**425,27**	**395,70**
Ukraine - Other (LV, HV, EHV, exceptional events)				337,53	261,60
Ukraine - Aggregated				762,80	657,30

TABLE 43 | UNPLANNED SAIFI (all events) - Contribution of MV to aggregated value

CP	2006	2007	2008	2009	2010
Bosnia and Herzegovina - MV				**9,17**	**8,47**
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				2,68	3,52
Bosnia and Herzegovina - Aggregated				11,85	11,99
Croatia - MV	**2,21**	**2,06**	**1,57**	**1,77**	**1,60**
Croatia - Other (LV, HV, EHV, exceptional events)	1,76	1,67	1,45	1,22	1,19
Croatia - Aggregated	3,97	3,73	3,02	2,99	2,79
Ukraine - MV				**2,45**	**2,81**
Ukraine - Other (LV, HV, EHV, exceptional events)				1,38	1,46
Ukraine - Aggregated				3,83	4,27

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