

## 4<sup>th</sup> Benchmarking Report on Quality of Electricity Supply - Voltage Quality Monitoring - Costs due to Voltage Disturbances

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## Content

- Introduction
- Survey's on customers' costs due to voltage disturbances
- Monitoring systems in place
- Voltage quality data



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## EERs' documents on voltage quality

### Important documents:

- Third CEER Benchmarking Report on Quality of Electricity Supply
- Towards Voltage Quality Regulation
  - An ERGEG Public Consultation paper
  - Evaluation of comments received
  - An ERGEG Conclusions Paper
- Service Quality Regulation in Electricity Distribution and Retail
  - Joint effort by CEER and FSR
- 4th CEER Benchmarking Report on Quality of Electricity Supply
- Energy Regulators' pledge to ensuring good quality of electricity supply





## 4th Benchmarking Report on Quality of Electricity Supply

- Three main chapters
  - Contains information from 27 countries within the EU and EEA (Malta and Bulgaria missing)
- Continuity of supply
  - Introduction, monitoring, indicators, audits, analysis, exceptional events
- Voltage quality
  - Introduction, ongoing work, regulation, surveys on costs, monitoring systems and data
- Commercial quality
  - Introduction, Connection, Customer care, Technical service, Metering and billing, regulations/standards, market opening



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## Survey on costs related to voltage disturbances

- **Norway, 2002 (inhabitants, ca 4.8 M):**
  - Estimated annual costs due to dips for end-users to be between 170 and 330 MNOK
- **Sweden, 2003 (inhabitants, ca 9 M)**
  - Estimated annual costs for industrial customers due to dips and interruptions at about 157 M€
- **Italy, 2006 (inhabitants, ca 58 M)**
  - Estimated annual costs due to dips and interruptions (< 1 sec) for the whole production system to be between 465 and 780 M€
- **PAN European LPQI Power Quality Survey**
  - Costs of PQ wastage EU-25 exceeds 150 bln € annually



## Norwegian survey - costs due to voltage dips

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

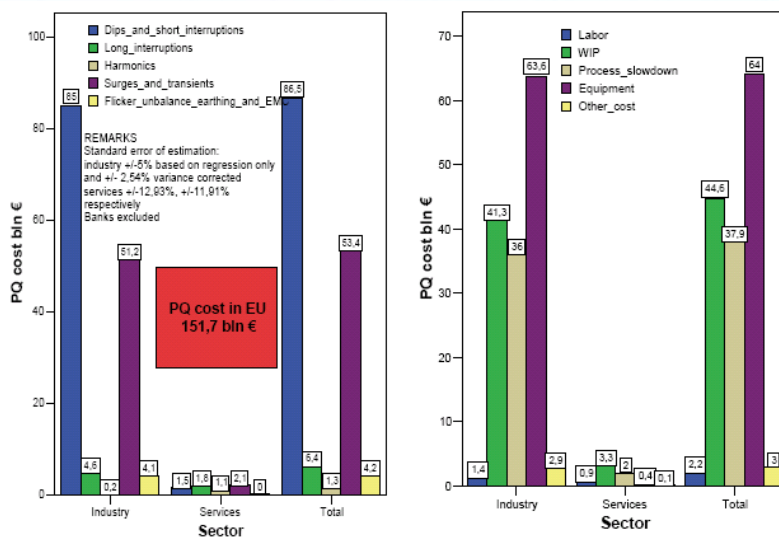


## Italian survey - costs due to voltage dips and interruptions (<1sec)

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



## Pan European survey - costs due to PQ disturbances





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

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

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

<sup>(1)</sup> Several monitoring instruments to perform yearly at least 60 measurements of one week each at both the MV and LV network.  
<sup>(2)</sup> In Norway a previous voluntary monitoring campaign was also carried out 1993-2003; see annex for more information.  
<sup>(3)</sup> In Portugal the number of units has been increasing since 1999; the first year that ERSE received information about voltage quality characteristics.

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

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

Country	Initiative
Belgium	TSO and DSOs
Czech Republic	TSO and DSOs
Denmark	DSO
Greece	Regulator
France	TSO and DSOs
Hungary	Regulator
Italy	Regulator
Lithuania	TSOs and DSOs
Luxembourg	TSOs and DSOs
The Netherlands	TSOs and DSOs
Norway	Regulator
Portugal	Quality and Service Code issued by General Directorate of Energy and Geology

Regulatory framework for individual verification	Country
<i>Distribution companies compelled to provide voltage quality individual measurements when requested by the customer or after complaints.</i>	<i>AT, BE, CY, CZ, DE, EE, FI, FR, HU, IT, LT, LV, NO, PL, RO, PT</i>
<i>Proposal stage</i>	<i>SE</i>
<i>No legal obligation</i>	<i>EE, ES, LU, SL, UK</i>





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## Data reported

- Six countries reported data on voltage dips
- Two countries reported data also for other disturbances (annex)
- Non-comparable data

TABLE 3.24 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN LV NETWORKS WITH REFERENCE TO MEASURING SITES							
Residual voltage u (%)	Duration t (ms)						
	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000	
90 > u ≥ 85	17	14	4	3	0	0	
85 > u ≥ 70	9	2	2	0	0	0	
70 > u ≥ 40	10	3	0	0	0	0	
40 > u ≥ 1	6	1	0	0	0	0	
1 > u	3	4	1	0	0	0	


TABLE 3.25 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN MV NETWORKS WITH REFERENCE TO MEASURING SITES							
Residual voltage u (%)	Duration t (ms)						
	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000	
90 > u ≥ 85	13	9	3	1	0	0	
85 > u ≥ 70	5	2	1	0	0	0	
70 > u ≥ 40	7	2	0	0	0	0	
40 > u ≥ 1	4	0	0	0	0	0	
1 > u	1	2	1	0	0	4	

TABLE 3.26 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN HV NETWORKS WITH REFERENCE TO MEASURING SITES							
Residual voltage u (%)	Duration t (ms)						
	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000	
90 > u ≥ 85	9	6	2	0	0	0	
85 > u ≥ 70	3	1	1	0	0	0	
70 > u ≥ 40	4	0	0	0	0	0	
40 > u ≥ 1	1	0	0	0	0	0	
1 > u	1	1	0	0	0	1	

TABLE 3.27 NORWAY: AVERAGE NUMBER OF VOLTAGE DIPS PER YEAR IN EHV NETWORKS WITH REFERENCE TO MEASURING SITES							
Residual voltage u (%)	Duration t (ms)						
	20 ≤ t ≤ 100	100 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 3,000	3,000 < t ≤ 20,000	20,000 < t ≤ 60,000	
90 > u ≥ 85	3	2	1	0	0	0	
85 > u ≥ 70	1	1	0	0	0	0	
70 > u ≥ 40	1	0	0	0	0	0	
40 > u ≥ 1	0	0	0	0	0	0	
1 > u	0	0	0	0	0	1	




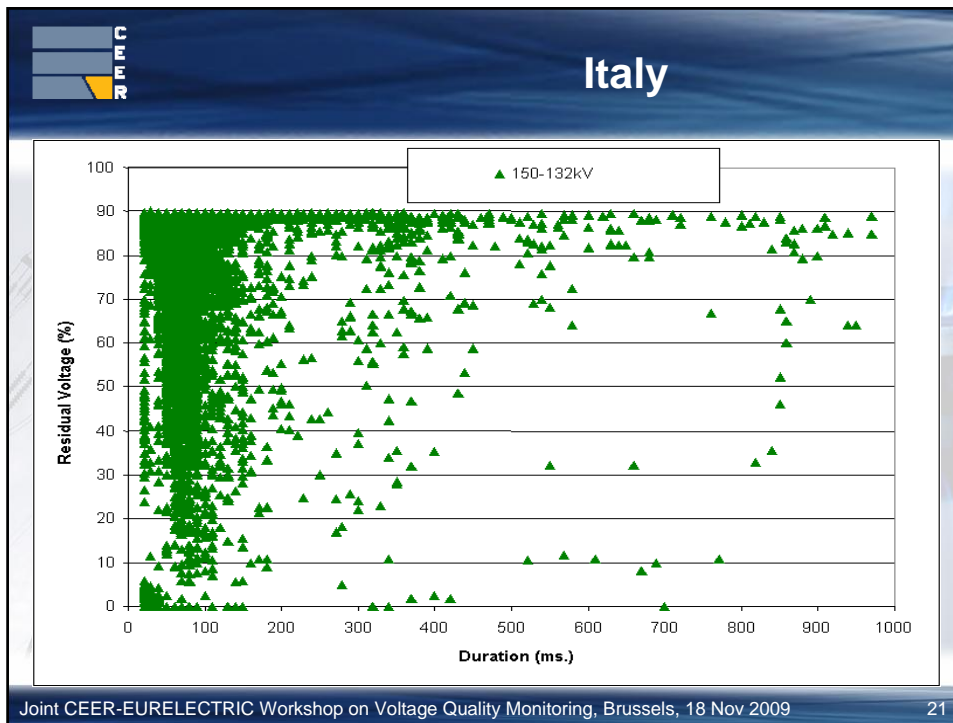
# Portugal

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

In brackets is the average number of dips per measuring unit





- ## Conclusions 4th BR VQ ch
- Voltage quality needs to be regulated
  - Individual verification of voltage quality to customers
  - Countries should consider monitoring voltage quality continuously and publish results regularly.
    - Dissemination of experiences and harmonisation is envisaged
    - Workshop on voltage quality monitoring
  - 11 countries reported monitoring schemes
  - 6 countries reported actual voltage quality data
  - Continued cooperation with CENELEC and further revisions of the EN 50160
- Joint CEER-EURELECTRIC Workshop on Voltage Quality Monitoring, Brussels, 18 Nov 2009 22



Thank you for your attention!

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