ANNEX A
ELECTRICITY – CONTINUITY OF SUPPLY

TABLE A.1 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		48,105	34,316	38,764	55,765	56,648	42,889	41,646	36,127	28,636	33,807	33,614	33,438
Bulgaria							288,5	231,2	197,24				
Croatia					577,84	250,95	237,24	204,62	188,94	151,95	196,84	176,13	166,34
Cyprus											148		
Czech Republic			102,54	120,5	102,5	124,23	86,7	102,65	106,24	107,08	109,93	98,01	84,31
Denmark							16,45	15,29	15,17	16,09	14,75	11,25	11,55
France	40	51	50,7	52,2	71,5	57,7	62,6	67,2	62,9	52,6	60,1	68,1	50,2
Germany					21,53	19,25	16,89	14,63	14,9	15,31	15,91	15,32	12,28
Great Britain	81,66	81,28	76,59	68,64	65,55	78,03	74,22	73,43	70,02	67,95	55,43	54,71	53,06
Greece							167	138	121	101	101	96	92
Hungary	196,8	155,4	137,4	121,8	127,75	137,42	97,7	99,32	102,38	75,73	76,25	67,21	74
Ireland	183	162	156,5	154,9	123,9	115,4	94,1	81,3	82	69,6	62	86,7	101,1
Italy	108,88	96,83	76,52	65,74	53,84	52,47	53,1	49,45	47,77	43,59	45,45	42,27	41,32
Latvia												192	153
Lithuania				149,85	125,75	135,55	103,37	87,71	83,38	106,1	76,58	72,67	71,56
Luxembourg										13,2	17,7	16,7	14,2
Malta	523,8	566,98	486,83	398,82	304,37	409	186,58	687,85	620,57	191	286,2	360,04	570,6
The Netherlands	28	30	24	27,4	35,6	33,1	22,1	26,5	33,7	23,4	27	23	20
Poland							354,51	316,46	316,26	309,1	254	254,85	191,77
Portugal	334,54	303,75	148,81	142,82	152,08	104,33	133,08	185,62	172,98	97,25	78,48	88,7	74,89
Romania							638	635	639	547	630	427	361
Slovenia							59	54	51	64	75	60	71
Spain	142,557	141,908	123,6	117	112,8	103,92	86,82	90	79,2	58,2	62,4	52,08	54
Sweden									79,3	118,34	84,02	82,18	74,59
Switzerland									13	16	21	15	13

Notes:

Austria: 2002 without flood, 2006 without UCTE-blackout on 4th of November, 2007 without interruptions caused by storm "Kyrill", 2008 storm "Paula" and "Emma", 2013 flood, 2014 snowstorm, storms "Yvonne", "Gonzalo".

Denmark: Interruptions lasting 1 minute or more are monitored.

France: All SAIDI, SAIFI and MAIFI figures only include customers covered by the main DSO (ERDF), which operates about 95% of French distribution networks.

Great Britain: This is based on equal to and greater than 3 minutes.

Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.

Hungary: Only for HV, MV and LV.

Ireland: These are the storm adjusted values for all of the distribution network.

Italy: Excluding force majeure and interventions of transmission defence systems.

Malta: Interruption data is available only from 11 kV level and above. No exceptional events.

Portugal: Indicator evaluated in LV; Interruptions not attributable to force majeure.

Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIDI on the EHV/HV level, the MV data only is used. Includes the interruptions attributable to "third party".

TABLE A.2 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		0,777	0,652	0,795	0,986	0,919	0,803	0,775	0,763	0,561	0,679	0,656	0,624
Bulgaria							5,63	5,12	4,65				
Croatia					3,43	3,06	2,58	2,48	2,27	2,06	2,36	1,94	1,83
Cyprus											0,8		
Czech Republic			2,11	1,92	1,87	2,35	1,7	1,63	1,64	1,65	1,82	1,69	1,6
Denmark							0,41	0,36	0,39	0,4	0,4	0,3	0,31
France	1,15	1,4	1,3	1,02	1,3	0,98	1,16	1	0,92	0,81	0,89	0,87	0,73
Germany					0,456	0,326	0,322	0,289	0,263	0,311	0,275	0,47	0,34
Great Britain	0,866	0,7886	0,8073	0,7241	0,7165	0,7802	0,7345	0,7138	0,6894	0,6792	0,5986	0,5889	0,595
Greece							2,1	2,1	2,1	2	1,8	1,6	1,7
Hungary	2,03	2,05	1,9	1,77	1,77	1,88	1,54	1,49	1,45	1,21	1,16	1,04	1,067
Ireland	1,242	1,466	1,679	1,862	1,43	1,485	1,282	1,082	1,178	0,946	0,857	1,142	1,285
Italy	2,74	2,68	2,42	2,333	2,226	2,1	1,923	1,945	1,802	1,669	1,74	1,632	1,646
Latvia												2,9	2,38
Lithuania				1,36	1,36	1,54	1,38	1,28	1,15	1,13	1,06	0,97	0,9
Luxembourg										0,35	0,3	0,27	0,23
Malta	4,4145	5,211	4,688	4,63	2,8867	4,2434	2,3521	5,0435	5,5012	2,6634	4,2833	4,13	2,754
The Netherlands	0,34	0,34	0,32	0,304	0,454	0,33	0,307	0,331	0,384	0,341	0,316	0,296	0,276
Poland							4,08	3,7	3,74	4,14	3,42	3,02	2,95
Portugal	5,93	4,81	2,69	2,71	2,73	2,06	2,36	2,77	3,14	1,94	1,62	1,75	1,56
Romania							6,7	6,4	6,1	5,6	5,5	4,8	4,35
Slovak Republic											2,15	2,03	
Slovenia							1,8	1,49	1,39	1,63	2,16	1,59	1,89
Spain	2,65	2,599	2,52	2,31	2,38	2,229	1,991	2,033	1,816	1,415	3,202	1,31	1,112
Sweden									2,02	1,59	1,33	1,288	1,299
Switzerland									0,28	0,28	0,34	0,28	0,22

Notes:

Austria: 2002 without flood, 2006 without UCTE-blackout on 4th of November, 2007 storm "Kyrill", 2008 storm "Paula" and "Emma", 2014 snowstorm, storms "Yvonne", "Gonzalo".

Denmark: Interruptions lasting 1 minute or more are monitored.

France: All SAIDI, SAIFI and MAIFI figures only include customers covered by the main DSO (ERDF), which operates about 95% of French distribution networks.

Great Britain: This is based on equal to and greater than 3 minutes. GB originally submitted CI values per 100 customers. The values in this table are the CI values divided by 100.

Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.

Hungary: Only for HV, MV and LV.

Ireland: These are the storm adjusted values for all of the distribution network. The values originally submitted by Ireland (per 100 customers per year) were divided by 100.

Italy: Excluding force majeure and interventions of transmission defence systems.

Malta: Interruption data is available only from 11 kV level and above. No exceptional events. The values originally submitted were divided by 100.

Portugal: Indicator evaluated in LV Interruptions not attributable to force majeure.

Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIDI on the EHV/HV level, the MV data only is used. Includes the interruptions attributable to "third party".

Sweden: Interruptions over 12 hour are not included. In Sweden, exceptional events are not defined, but interruptions with duration of at least 12 hours are excluded due to economical compensation for those interruptions. All interruptions, however, do include those longer than 12 hours.

TABLE A.3 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: HV+EHV (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					13,48	13,41	9,49	10,36	8,16	5,37	22,83	5,99	5,83
Czech Republic									2,9	10,41	2,26	10,34	1,41
Denmark							0,15	0,25	0,16	0,08			
France	1,9	2,2	1,5	6,7	7,5	2,1	6,1	5,6	1,5	1,1	2	2	1,8
Hungary		4,11	1,45	1,29	2,37	0,29	0,56	0,66	0,21	0,33	0,56	0,41	0,323
Ireland	5,3	11,8	16,2	17,4	10,9	19,6	10,4	9	8	6,1	2,8	9,2	8,5
Italy	2,28	2,6	4,469	2,8	2,22	3,384	1,662	1,613	2,846	2,342	1,328	1,927	2,883
Lithuania				0	4,65	15,24	1,18	1,42	2,89	0,92	0,26	0,22	1,9
The Netherlands	6,3	2,8	2,2	7,6	8,2	11,3	1,4	3,2	7,9	3	1	0,8	0,9
Sweden									14,986	21,214	12,632	23,876	54,167
Switzerland									4	2	6	1	2

Notes:
Croatia: In this case, HV is only related to the 110 kV voltage level.
Ireland: These are values for 110 kV and 38 kV distribution network.

TABLE A.4 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: MV (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					539,83	197,42	210,2	178,42	162,83	121,92	145,27	144,25	113,63
Czech Republic							88,54	119,92	124,58	114	105,8	97,88	97,74
Denmark							13,56	12,58	12,37	13,2	11,97	10,02	8,89
France	31	40	40,6	36,8	54,8	47,1	47,4	50,5	51	42,6	47,1	54,7	39,4
Hungary	139,24	104,96	99,72	83,77	86,45	98,49	70,31	66,46	74,13	52,94	48,98	48,34	49,54
Ireland	135,4	129,6	126,1	123,8	101,7	85,4	75	65,8	67,8	57,1	54,9	72,2	87,3
Italy	80,59	73,85	56,29	46,7	36,01	33,32	32,4	31,15	28,46	26,12	27,31	25,36	24,49
Lithuania				32	89,79	89,18	75,23	65,23	63,06	64,43	59,14	56,84	54,82
The Netherlands	17,7	22,6	17,7	15,5	21,8	17,1	15,8	18	19	14,6	19	15,9	12,8
Sweden									99,219	110,855	69,301	123,13	102,219
Switzerland									7	12	12	12	10

Notes:
The Netherlands: 1-20 kV.

TABLE A.5 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: LV (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					24,53	40,12	17,55	15,83	17,95	24,66	28,73	25,89	18,79
Czech Republic							82,8	102,58	106,17	107,06	109,95	98,02	84,33
Denmark							2,3	2,18	2,03	2,12	2,08	1,77	1,82
France	7	9	8,7	8,8	9,2	8,5	9,1	11,1	10,4	8,9	10,9	11,4	8,9
Hungary	57,56	46,33	40,43	36,75	38,93	38,63	26,82	32,2	28,03	22,47	21,83	18,47	24,473
Ireland	42,4	20,6	14,2	13,8	11,3	10,4	8,6	6,5	6,3	6,4	4,4	5,3	6,2
Italy	26,01	20,38	15,76	16,24	15,61	15,76	19,04	16,69	16,15	14,86	16,26	14,51	13,59
Lithuania				118,03	31,01	30,84	26,97	19,55	17,44	19,32	17,18	15,6	14,84
The Netherlands	4,3	4,9	4,3	4,3	4,6	4,8	4,9	5,3	6,3	5,8	7	6,7	6,3
Sweden									91,88	186,43	88,21	151,99	83,82
Switzerland									2	2	2	2	1

TABLE A.6 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: HV+EHV (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					0,52	0,4	0,45	0,32	0,25	0,16	0,36	0,15	0,15
Czech Republic									0,18	0,09	0,15	0,21	0,11
Denmark							0,04	0,03	0,02	0,01			
France			0,06	0,11	0,22	0,05	0,11	0,12	0,06	0,05	0,07	0,07	0,05
Hungary		0,1	0,07	0,085	0,077	0,035	0,039	0,058	0,013	0,047	0,019	0,028	0,028
Ireland	0,062	0,334	0,569	0,29	0,264	0,361	0,184	0,148	0,161	0,14	0,094	0,17	0,211
Italy	0,17	0,16	0,2	0,217	0,187	0,218	0,136	0,127	0,12	0,093	0,107	0,119	0,157
Lithuania				0	0,08	0,15	0,05	0,06	0,05	0,02	0,01	0,004	0,03
The Netherlands	0,129	0,101	0,083	0,096	0,159	0,093	0,079	0,092	0,129	0,11	0,059	0,05406	0,04
Sweden									0,295	0,36	0,204	0,36	0,658
Switzerland									0,08	0,07	0,1	0,08	0,06

Notes:
Croatia: In this case, HV is only related to the 110 kV voltage level.
Ireland: These are values for 110 kV and 38 kV distribution network. The values originally submitted by Ireland (per 100 customers per year) were divided by 100.

TABLE A.7 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: MV (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					2,72	2,44	1,97	2,03	1,88	1,71	1,8	1,63	1,03
Czech Republic							1,45	1,82	1,95	1,93	1,88	1,78	1,78
Denmark							0,34	0,31	0,34	0,36	0,36	0,33	0,27
France			0,94	0,86	1,04	0,88	1,01	0,82	0,81	0,72	0,77	0,75	0,63
Hungary	1,57	1,53	1,46	1,38	1,38	1,54	1,27	1,21	1,24	1,002	0,986	0,86	0,893
Ireland	0,939	1,003	1,033	1,486	1,103	1,061	1,048	0,898	0,983	0,768	0,741	0,946	1,06
Italy	2,41	2,35	2,052	1,951	1,874	1,711	1,58	1,61	1,473	1,365	1,379	1,281	1,268
Lithuania				0,99	1,02	1,11	1,02	0,95	0,88	0,85	0,83	0,79	0,72
The Netherlands	0,184	0,214	0,208	0,18	0,234	0,202	0,193	0,201	0,213	0,191	0,214	0,19948	0,197
Sweden									0,96	1,2	0,94	1,074	1,03
Switzerland									0,17	0,2	0,22	0,19	0,14

Notes:
Ireland: The values originally submitted by Ireland (per 100 customers per year) were divided by 100.

TABLE A.8 UNPLANNED INTERRUPTIONS EXCLUDING EXCEPTIONAL EVENTS: MV (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Croatia					0,19	0,21	0,16	0,13	0,14	0,19	0,2	0,16	0,13
Czech Republic							1,6	1,63	1,64	1,65	1,82	1,69	1,6
Denmark							0,02	0,02	0,02	0,02	0,02	0,01	0,02
France			0,05	0,05	0,05	0,05	0,04	0,05	0,05	0,04	0,05	0,05	0,04
Hungary	0,46	0,42	0,37	0,31	0,31	0,31	0,22	0,22	0,2	0,16	0,16	0,15	0,144
Ireland	0,241	0,129	0,078	0,086	0,063	0,062	0,049	0,036	0,035	0,038	0,023	0,026	0,025
Italy	0,16	0,17	0,171	0,164	0,162	0,171	0,207	0,207	0,209	0,193	0,226	0,212	0,195
Lithuania				0,28	0,27	0,28	0,31	0,27	0,23	0,26	0,22	0,18	0,16
The Netherlands	0,023	0,028	0,029	0,028	0,035	0,035	0,035	0,036	0,041	0,04	0,043	0,04252	0,038
Sweden									1,32	1,63	1,33	1,33	1,3
Switzerland									0,02	0,02	0,02	0,02	0,01

Notes:
Ireland: The values originally submitted by Ireland (per 100 customers per year) were divided by 100.

TABLE A.9 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		51,532	34,316	43,454	55,765	83,98	57,601	43,634	36,127	28,682	35,545	39,286	51,953
Belgium										36,18	39,45	34,75	26,15
Croatia					669,49	375,35	330,91	296,26	306,97	250,59	372,49	306,03	411,57
Cyprus											243,16		
Czech Republic							185,54	210,94	135,88	114,08	125,21	195,08	120,89
Denmark							16,48	15,29	15,18	17,04	14,75	15,86	11,59
Estonia					243,49	185,83	405,33	186,69	406	346	170,9	378,5	117,1
Finland	284	212	105	87	64	53	59	41	170	225	68	138	67
France	42	69,3	57,1	55,9	86,3	61,6	74,1	173,8	95,1	53,9	62,9	83,6	51,5
Germany					23,25	35,67	16,96	15,29	20,01	17,25	17,37	32,75	13,5
Great Britain	83,69	110,38	81,11	94,29	69,16	103,48	81,94	75,69	81,42	70,02	68,05	61,02	92,51
Greece									163	166	150	133	122
Hungary	196,8	155,4	137,4	121,8	127,75	141	111	125	132,59	85,12	76,89	138,53	86
Ireland	230,2	171,9	162,8	163,6	148,3	129,7	108,9	100,4	110	76,4	67,7	134,3	420,2
Italy	114,74	546,08	90,53	79,86	60,55	57,89	89,64	78,67	88,84	107,96	132,73	105,4	93,8
Latvia						269	236	424	1073	708	371	341	210
Lithuania				373,57	168,7	301,7	155,65	161,3	260,03	302,59	287,73	153,93	144,04
Luxembourg										13,2	17,7	16,7	14,2
Malta	523,8	566,98	486,83	398,82	304,37	409	186,58	687,85	620,57	191	286,2	360,04	570,6
The Netherlands	28	30	24	27,4	35,6	33,1	22,1	26,5	33,7	23,4	27	23	20
Norway				93	113	96	104	84	66	216	66	144	118
Poland						410	440,64	378,35	386,18	325,76	263,19	281,82	205,41
Portugal	467,98	406,18	217,79	198,73	243,19	136	162,67	280,03	276,04	131,43	94,15	258,8	94,75
Romania							696	682	657	547	668	475	468
Slovak Republic											188,87	187,14	
Slovenia							116	133	81	76	169	109	908
Spain	142,557	141,908	123,6	117	112,8	103,8	86,82	133,86	140,88	58,2	62,4	52,08	52,62
Sweden	101,8	148,1	78,1	912,6	100	321,9	110,8	73,3	92,3	186,46	89,01	151,94	83,85
Switzerland									14	16	22	15	13

Notes:
Cyprus: Figure refers to HV, MV and LV.
Finland: T-SAIDI.
Great Britain: This is based on equal to and greater than 3 minutes.
Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.
Hungary: Only for HV, MV and LV.
Ireland: These are the values for all of the distribution network.
Italy: The 2003 figure includes two nation-wide events (September blackout and June rolling blackouts).
Latvia: This information is only for MV and LV networks.
Malta: Calculated at 11 kV and include interruptions at this level or upstream.
Norway: LV events are included from 2014.
Portugal: Indicator evaluated in LV interruptions not attributable to force majeure.
Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIDI on the EHV/HV level, the MV data only is used.

TABLE A.10 UNPLANNED INTERRUPTIONS INCLUDING ALL EVENTS (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		0,798	0,652	0,806	0,986	1,057	0,892	0,788	0,763	0,562	0,698	0,682	0,822
Belgium										0,74	0,81	0,72	1,04
Croatia					4,2	4,06	3,28	3,24	2,96	2,7	3,12	2,7	2,71
Cyprus											0,8		
Czech Republic							2,22	2	1,78	1,82	1,9	2,13	1,86
Denmark							0,42	0,36	0,39	0,4	0,4	0,37	0,31
Estonia					1,544	2,045	4,558	1,835	2,072	1,974	1,793	2,487	0,648
Finland	3,3	4	4,3	1,9	1,8	1,6	1,6	1,2	1,8	2,4	1,8	2,5	1,6
France	1,2	1,43	1,3	1,08	1,33	0,98	1,18	1,1	0,98	0,82	0,9	0,9	0,74
Germany					0,456	0,425	0,334	0,298	0,315	0,337	0,29	0,5	0,37
Great Britain	0,871	0,8625	0,8257	0,7837	0,7444	0,8802	0,7681	0,7286	0,7182	0,6917	0,6494	0,6108	0,7211
Greece									2,8	2,9	2,6	2,4	2,2
Hungary	2,03	2,05	1,9	1,77	1,79	1,92	1,62	1,69	1,63	1,26	1,17	1,15	1,133
Ireland	1,367	1,497	1,703	1,947	1,595	1,57	1,387	1,196	1,317	1,021	0,907	1,39	1,664
Italy	2,76	3,96	2,48	2,419	2,29	2,156	2,38	2,364	2,265	2,082	2,334	2,202	1,994
Latvia						2,18	2,01	0,9	4,15	4,74	3,84	3,52	2,78
Lithuania				1,74	1,65	2,18	1,73	1,74	1,92	2,19	1,82	1,43	1,29
Luxembourg										0,35	0,3	0,27	0,23
Malta	4,4145	5,211	4,688	4,63	2,8867	4,2434	2,3521	5,0435	5,5012	2,6634	4,2833	4,13	2,754
The Netherlands	0,34	0,34	0,32	0,304	0,454	0,33	0,307	0,331	0,384	0,341	0,316	0,296	0,276
Norway				1,54	1,75	1,7	1,79	1,7	1,5	2,4	1,4	2	2,2
Poland						3,1	4,14	3,84	3,77	4,22	3,44	3,32	2,96
Portugal	7,35	5,96	3,66	3,54	3,81	2,62	2,8	3,63	4,32	2,41	1,88	3,09	1,89
Romania							6,9	6,5	6,1	5,6	5,5	5,1	5,1
Slovenia							2,71	2,4	1,81	1,81	2,99	2,2	4,31
Spain	2,65	2,599	2,52	2,31	2,38	2,23	1,991	2,192	1,956	1,417	3,202	1,31	1,127
Sweden	1,838	1,64	1,1	1,49	1,28	1,7	1,38	1,32	2,02	1,63	1,33	1,33	1,3
Switzerland									0,29	0,28	0,34	0,29	0,22

Notes:
Cyprus: Figure refers to HV, MV and LV.
Denmark: Interruptions lasting 1 minute or more are monitored.
Finland: T-SAIFI.
Great Britain: This is based on equal to and greater than 3 minutes. GB originally submitted CI values per 100 customers. The values in this table are the CI values divided by 100.
Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.
Hungary: Only for HV, MV and LV.
Ireland: These are the values for all of the distribution network. The values originally submitted by Ireland (per 100 customers per year) were divided by 100.
Italy: The 2003 figure includes two nation-wide events (September blackout and June rolling blackouts). SAIFI is not affected by thefts.
Latvia: This information is only for MV and LV networks.
Malta: Calculated at 11 kV and include Calculated at 11 kV and include interruptions at this level or upstream. Calculated per 100 customers. The values originally submitted by Malta were divided by 100.
Norway: LV events are included from 2014.
Portugal: Indicator evaluated in LV interruptions not attributable to force majeure.
Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIFI on the EHV/HV level, the MV data only is used.

TABLE A.11 PLANNED INTERRUPTIONS (MINUTES LOST PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		13,904	15,637	19,902	20,044	20,052	16,807	16,223	17,26	16,383	14,865	14,35	16,355
Bulgaria							299,5	289,7	224,21				
Croatia					499,56	421,7	412,72	287,78	293,43	308,5	295,45	253,49	250,15
Czech Republic			148,29	166,19	144,7	150,23	165,82	140,65	159,4	154,73	147,59	159,68	162,33
Denmark							8,76	8,37	5,37	4,94	4,76	4,7	5,05
Estonia					118,59	202,2	195,26	145,04	120,6	104,1	84,93	86,84	66
Finland				23	26	23	23	18	17	19	21	41	13
France	6	5,3	6,6	8	7,9	10,8	19,4	23,2	24	18,9	15,6	15,9	15,8
Germany					15,1	13,85	13,17	11,53	9,66	10,12	11,83	7,23	7,56
Great Britain					4,06	4,96	5,7	6,48	6,72	6,69	6,7	5,68	5,72
Greece								232	195	163	147	151	136
Hungary	137,02	199,24	178,95	138,5	139,86	144,66	156,99	198,17	179,65	156,55	153,41	122,76	132
Ireland	284,1	422,3	390,7	375,4	268,7	79	60,5	59,3	64,1	46,6	44,9	42,1	42,3
Italy	77,97	80,67	62,62	58,77	53,79	46,16	49,35	43,58	55,71	61,85	65,97	55,28	59,6
Latvia						237	261	254	219	236	265	280	256
Lithuania				113,62	98,27	71,23	78,07	93,29	132,72	157,9	179,2	212,76	217,45
Luxembourg										2	2,6	1	1,2
Malta	89,38	72,84	69,28	105,63	94,74	78,88	72,73	75,1	72,6	69,08	80,32	61,04	207
The Netherlands					2,81	3,39	4,13	4,04	4,35	5,1	5,17	6,016	5,888
Norway				44	42	48	44	42	36	42	41	36	43
Poland						121	149,05	140,31	129,7	153,05	147,32	139,12	119,4
Portugal	52,21	62,39	49,16	39,16	18,7	7,31	2,07	2	1,57	2,05	1,68	1,46	2,59
Romania							385	323	324	333	246	270	230
Slovak Republic											188,87	187,14	
Slovenia							138	130	104	126	117	115	119
Spain	30,656	24,791	21,6	13,8	9,6	11,4	10,8	8,34	8,82	9	18,42	19,62	10,6
Sweden	37,1	25,4	24,8	33,5	23,8	23,2	26,4	21,3	20,1	16,7	16,94	18,87	18,2
Switzerland									14	13	12	10	9

Notes:
Denmark: Interruptions lasting 1 minute or more are monitored.
Finland: T-SAIDI.
Great Britain: These are finalised performance values which have weightings applied to them. Under British incentive, a 50% weighting is applied to CI and CML values for planned interruptions to recognise that these are less inconvenient than an unplanned interruption.
Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.
Hungary: Only for HV, MV and LV.
Ireland: These are the values for all of the distribution network.
Latvia: This information is only for MV and LV networks.
Malta: Calculated at 11 kV and include interruptions at this level or upstream.
Norway: LV events are included from 2014.
Portugal: Indicator evaluated in LV Interruptions not attributable to force majeure or exceptional events.
Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIDI on the EHV/HV level, the MV data only is used.

TABLE A.12 PLANNED INTERRUPTIONS (INTERRUPTIONS PER YEAR)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria		0,14	0,163	0,206	0,195	0,235	0,165	0,161	0,156	0,15	0,133	0,127	0,141
Bulgaria							5,25	5,29	3,61				
Croatia					2,96	2,58	2,25	2,02	2,12	2,14	2	1,63	1,63
Czech Republic			0,57	0,57	0,55	0,56	0,62	0,54	0,59	0,54	0,5	0,52	0,51
Denmark							0,06	0,07	0,05	0,04	0,04	0,04	0,04
Estonia					0,521	0,498	1,314	0,581	0,509	0,525	0,53	0,571	0,478
Finland				0,3	0,4	0,4	0,3	0,3	0,3	0,3	0,3	0,4	0,2
France	0,04	0,04	0,05	0,06	0,06	0,11	0,21	0,24	0,21	0,13	0,11	0,13	0,13
Germany						0,126	0,104	0,101	0,089	0,102	0,116	0,076	0,08
Great Britain					0,0183	0,0204	0,0227	0,0254	0,0262	0,0262	0,0263	0,0229	0,0229
Greece								1,2	1	1	0,8	0,9	0,7
Hungary	0,54	0,75	0,71	0,54	0,57	0,55	0,59	0,66	0,61	0,55	0,54	0,43	0,45
Ireland	0,659	0,764	0,674	0,89	0,684	0,284	0,241	0,237	0,251	0,181	0,185	0,166	0,167
Italy	0,49	0,49	0,4	0,374	0,34	0,303	0,347	0,292	0,384	0,373	0,409	0,368	0,358
Latvia						0,83	0,94	0,9	0,85	0,85	0,94	0,96	0,99
Lithuania				0,4	0,36	0,25	0,26	0,33	0,47	0,48	0,53	0,54	0,56
Luxembourg										0,03	0,03	0,04	0,04
Malta	0,9304	0,9687	0,7214	1,97	0,9888	0,5909	0,54	0,4611	0,82	0,5278	0,7705	0,63	0,858
The Netherlands					0,018	0,022	0,027	0,024	0,027	0,031	0,031	0,0338	0,0324
Norway				0,32	0,3	0,3	0,32	0,3	0,3	0,3	0,27	0,3	0,3
Poland						0,4	0,74	0,76	0,68	0,82	0,7	0,62	0,56
Portugal	0,29	0,3	0,23	0,19	0,09	0,04	0,02	0,01	0,01	0,012	0,0076	0,0067	0,011
Romania							1,6	1,5	1,3	1,3	0,9	1	0,8
Slovenia							1,09	1,05	0,85	0,98	0,88	0,89	0,86
Spain	0,26	0,2015	0,19	0,09	0,08	0,09	0,076	0,06	0,06	0,057	0,323	0,302	0,07
Sweden	0,26	0,22	0,18	0,22	0,2	0,32	0,51	0,23	0,18	0,14	0,14	0,149	0,16
Switzerland									0,12	0,12	0,11	0,09	0,08

Notes:

Denmark: Interruptions lasting 1 minute or more are monitored.

Finland: T-SAIFI.

Great Britain: This is based on equal to and greater than 3 minutes. GB originally submitted CI values per 100 customers. The values in this table are the CI values divided by 100. They are finalised performance values which have weightings applied to them. Under British incentive, a 50% weighting is applied to CI and CML values for planned interruptions to recognise that these are less inconvenient than an unplanned interruption.

Greece: Figures refer to MV and LV voltage levels for all years. Figures for all years include non-interconnected islands.

Hungary: Only for HV, MV and LV.

Ireland: These are the values for all of the distribution network. These values are per 100 customers per year. The values originally submitted by Ireland were divided by 100.

Latvia: This information is only for MV and LV networks.

Malta: Calculated at 11 kV and include interruptions at this level or upstream. Calculated per 100 customers. The values originally submitted by Malta were divided by 100.

Portugal: Indicator evaluated in LV Interruptions not attributable to force majeure or exceptional events.

Slovenia: Due to unavailability of LV data, as well as different weighting method for calculation of SAIFI on the EHV/HV level, the MV data only is used.

TABLE A.13 DEFINITIONS OF EXCEPTIONAL EVENTS AND THEIR INCLUSION IN INTERRUPTION STATISTICS

Country	Regulatory definition of "Exceptional events"	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
Austria	Exceptional regional events mean events that according to previous experience cannot be expected to occur in a given region and during which facilities constructed and maintained with due care cannot be operated without failure.	Statistics with and without	
Belgium	The emergencies that justify the intervention of the network operator, may occur especially in the following unforeseen or exceptional circumstances: (1) natural disasters arising from earthquakes, floods, storms, cyclones or other climatically exceptional situations; (2) a nuclear or chemical explosion and its consequences (3) a computer virus or a computer crash; (4) temporary or permanent technical impossibility for the network to exchange electricity because of failures within the control area caused by electricity flows resulting from energy exchanges within another control area or between two or more other control areas and of which the identity the parties involved in this energy exchange is not known and cannot be reasonably known by the network operator; (5) the inability to use the grid due to a collective dispute that gives rise to unilateral action by employees (or groups of employees) or any other labour dispute; (6) fire, explosion, sabotage, terrorist acts, acts of vandalism, damage caused by criminal acts, criminal coercion and threats of the same nature; (7) state of war declared or not, threat of war, invasion, armed conflict, blockade, revolution or insurrection; (8) a measure from higher up; (9) sudden phenomena; (10) scarcity.	Excluded	
Bulgaria	Force majeure – an extraordinary event which (1) cannot 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 - ensuring from human activities: military activities, terrorism, embargo, prohibitions imposed by the government, strikes, riots, uprisings - of natural character: storms (which speed above 60 km/h), torrential rains, floods, hailstorms, thunderbolts, snow avalanches, landslides.	Excluded	No
Croatia	Force Majeure	Included	No
Cyprus	Unforeseen circumstances	Included	
Czech Republic	No definition, but there is an individual approach. According to public notice DSOs are allowed to ask for the approval by the regulator and report these events as "1.1.1.2. Under severe weather conditions" NRA evaluates the request and potentially approves it. Besides these events, indicators "without exceptional events" in this BM are lowered by other categories defined in 1.5.(ii)1., namely: 1.2. Enforced, 1.3. Exceptional, 1.4. Caused by event outside network or by producer.	Statistics with and without	No
Denmark	Force majeure due to storm surge, flood, hurricane or other incidents that DERA approves as force majeure.	Statistics with and without	Yes. If the extreme weather event is classified by the Danish Meteorological institute it will be classified as "Exceptional event".
Estonia	Long interruptions caused by events that network operator could not foresee (examples: 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. For climatic events, exceptional events definition is based on both: 1. wideness (simultaneous outage for more than 100,000 final customer); and 2. local occurrence of this type of climatic event (less than 1 / 20 years), according to meteorological data. Other cases of force majeure independent of system operators are also considered as exceptional events.	Statistics with and without	No

Country	Regulatory definition of "Exceptional events"	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
Germany	Force Majeure	Statistics with and without	No
Great Britain	Ofgem does have 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 (1 kV and above) faults in a licence area over a 24 hour period. These events further fall into three categories, namely medium, large and very large events (1).
Greece	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.
Hungary	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; and 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 "other event" by HEO. (e.g. strain exceeding the design requirements).	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 are above eight (I. category) or thirteen times (II. category) the number of the (8 year) average, then it is considered as an "extreme weather condition period" 2.Overall standards: strain exceeding the design requirements, e.g. wind speed over 100 km/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	Statistics with and without	Yes. In addition to document-proven force majeure (for transmission and for distribution), a statistical method is used for distribution network. It is rather complex, referring to the past number of interruptions in 6-hour periods.
Latvia	No	Statistics with and without	No
Lithuania	No	Included	No
Luxembourg	No		
The Netherlands	Examples of "extreme situations" are earthquakes, floods, extraordinary weather conditions, terrorist attacks and war.	Included	No
Norway	Exceptional events are defined in each individual case. NVE makes separate reports on larger events, Exceptional events are not treated separately in the annual interruption statistics.	Included	No
Poland	According to the definition of "Force majeure" given in the Transmission Grid Code approved by the regulator as exceptional are regarded the sudden events, unpredictable and independent from will of the parties, which makes it impossible to meet contractual obligations, wholly or partly, permanently or temporarily and whose effects cannot be anticipated, even with the due care of the parties. The manifestations of the Force majeure are in particular: natural disasters, including fire, flood, drought, earthquake, hurricane, hoar frost, the acts of state, including martial law, emergency state, embargoes, blockades, etc., acts of war, the acts of sabotage, acts of terrorism, general strikes or other social unrest, including public demonstrations, lockouts.	Statistics with and without	No

Country	Regulatory definition of "Exceptional events"	Exceptional events in interruption statistics	Statistical method to define "major event days" or "exceptional condition periods"
Portugal	An Exceptional Event is an interruption which satisfies the next four criteria (cumulative): (i) the cause of interruption and its consequences are non-predictable, (ii) leads to a considerable decrease in the continuity of supply of the system, (iii) it is non-economically efficient to avoid the interruption and its consequences, (iv) the origin of the interruption and its consequences are attributable to the network.	Included	The Quality of Service Code also establishes the definition of Great Impact Incident. An interruption is classified as a Great Impact Incident when its Not Supplied Energy is greater than 50 MWh. This definition exists only for monitoring purposes. All Great Impact Incidents must be reported to regulator through a detailed report describing the origin of incident and the actions performed by the operator to restore the steady-state of the network.
Romania	There is a general definition but the exceptional events/force majeure have 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
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 lead to declaration of crisis situation by the authorities), and which effects on continuity of supply cannot be predicted and prevented or avoided b) non-natural event (i.e. war), which lead to declaration of crisis situation by the authorities. An interruption of supply can be qualified under the force majeure only in cases where it was caused by the event beyond the control of system operator and in cases when system operator could not prevent or avoid the event (the cause was unpredictable, irresistible and external to the network). The system operator must have a written evidence that network design criteria have been exceeded for each interruption that is classified under the force majeure due to the more severe conditions than the ones considered at the network design requirements.	Statistics with and without	Yes. According to IEEE 1366:2003, but based on monthly interruption data, not daily.
Spain	Yes, Special event is authorised by the Directorate General for Energy and Mines, and has natural causes and that generally occurs in at least 10% of the municipalities on the peninsula or at least 50% of municipalities each island and peninsular systems and, in accordance with technical regulations applicable to facilities are not provided for in the design of them.	Included	Yes
Sweden	We do not have a definition of exceptional event, but when reporting data to the Benchmarking Report we classify interruptions with an interruption period of at least 12 hours as exceptional event because those interruptions are not considered in the economic regulation due to the law on economical compensation for those interruptions if the customers experience an outage of at least 12 hours.		No
Switzerland	1. low probability of occurrence 2. unavoidable 3. long interruption duration with many affected customers 4. following categories: weather, natural disaster, arrangement by authority, disaster (accident, explosion), influence of others / terrorism.	Excluded	No

(1) Medium events include 1) non lightning events where the number of faults equals or exceeds eight times the average number of daily high voltage faults but is less than 13 times the daily average and where less than 35% of customers have been affected, 2) lightning events where eight times the average daily high voltage faults or above have occurred but less than 35% of customers have been affected. Large events include non lightning events with a number of faults equal to or in excess of 13 times the daily average high voltage fault rate but where less than 35% of customers have been affected. Very large events include all events where more than 35% of customers have been affected. Events that are not related to weather are considered as exceptional if they are outside the companies' control and if more than 25,000 customers have been affected and/or more than 2 million customer minutes have been lost.

(2) An interruption is classified as exceptional event by the regulator after a request from the TSO or the DSO. The request must include a detailed description of the incident and the collected evidences, in order to prove that the four cumulative criteria for the classification as exceptional event are satisfied. The decision of the regulator is based on the analysis of the report and on the technical opinion of the department of the Ministry of Energy responsible for the networks licensing.

ANNEX B
ELECTRICITY – VOLTAGE QUALITY

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

France

- Supply voltage variations (HV, MV):
  - MV – 100% of time between Uc +/- 5%
  - LV – 100% of time between Un +/- 10%

Great Britain

- Power frequency – local areas (all voltage levels):
  - 50 Hz +/- 1%

- Power frequency – interconnected areas (all voltage levels):
  - 50 Hz +/- 1%

- Supply voltage variations (EHV, HV, MV, LV):
  - EHV – Uc +/- 10%
  - HV and MV – Uc +/- 6%
  - LV – Un +10% / - 6%

Ireland

- Supply voltage variations (HV, MV):
  - HV: For system with nominal voltage of 38 kV, the permitted range is 43 kV and 34.8 kV
  - MV: For system with nominal voltage of 20 kV, the permitted range is 21.8 kV and 19 kV
  - For system the nominal voltage of 10 kV, the permitted range is 10.9 kV and 9.5 kV

Italy

- Power frequency - local areas (HV):
  - 49.9 - 50.1 Hz under normal or alarm operational states
  - 49.5 - 50.5 Hz in Sicily and Sardinia islands
  - 47.5 - 51.5 Hz under emergency or restoration operational state

Malta

- Power frequency – local areas (all voltage levels):
  - 50Hz +/-1% (49.5 - 50.5 Hz) during 99.5% of the year
  - 50Hz +4% / -5% (47.5 - 52 Hz) during 100% of the time

- Supply voltage variations (HV, MV, LV):
  - HV: 132 kV +/- 6%
  - MV: 11 kV +/- 5%; 33 kV +5% / -10%
  - LV: 400/230 V +/- 10%

- Flicker severity (MV, LV):
  - Frequency of occurrence: 0.22 per min - 600 per min
  - $P_{st} < 0.7$ and $P_{lt} < 0.5$
  - Frequency of occurrence: 0.02 per min - 0.22 per min
  - Magnitude of up to 3% is permitted.
  - Frequency of occurrence: < 0.02 per min
  - Magnitude of up to 5% is permitted.

- Voltage dips (MV, LV):
  - A sudden reduction of the voltage to a value between 90% and 1% of the declared voltage followed by a voltage recovery after a short period of time.

- Voltage unbalance (LV):
  - In 3-phase network, a condition in which the rms values of the phase voltages or the phase angles between consecutive phases are not equal.
  - Limit - 1.3%

- Harmonic voltage (MV, LV):
  - 33 kV
  - THD ≤ 1.5%
  - 11 kV
  - THD ≤ 2%
  - 400/230 V
  - THD ≤ 2.5%

Norway

- Power frequency – local areas (EHV, 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 (EHV, 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 (EHV, HV, MV, LV):
  - Limits for P_{st} (short term flicker severity) 95% of the week:
  - MV and LV: 1.2 [pu]
  - EHV and HV: 1.0 [pu]
  - Limits for P_{lt} (long term flicker severity) 100 % of the time:
    - MV and LV: 1.0 [pu]
    - EHV and HV: 0.8 [pu]

- Transient overvoltages (EHV, HV, MV, LV): High frequency or over frequency overvoltages that normally lasts for less than one half cycle (10 ms). The rise time can vary from less than a microsecond up to a few milliseconds.

- Voltage dips (EHV, HV, MV, LV): See limits given for rapid voltage change

- Voltage swells (EHV, HV, MV, LV): See limits given for rapid voltage change

- Voltage unbalance (EHV, 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 (EHV, HV, MV, LV):
  - LV and MV: The TSO and the DSOs shall, in connection points with nominal voltages from 230 V to 35 kV, ensure that individual harmonic voltages, measured as ten-minute mean values, do not exceed the following values:

TABLE B.1 LIMIT VALUES FOR HARMONIC VOLTAGES FOR LV AND MV

Odd harmonics				Even harmonics	
Not multiple of 3		Multiple of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5	6.0 %	3	5.0 %	2	2.0 %
7	5.0 %	9	1.5 %	4	1.0 %
11	3.5 %	>9	0.5 %	>4	0.5 %
13	3.0 %				
17	2.0 %				
19, 23, 25	1.5 %				
>25	1.0 %				

- THD: 100% of the time ≤ 8% (10-min mean values) and ≤ 5% (1 week mean value)
  - HV and EHV ≤ 245 kV: The TSO and the DSOs shall, in connection points with nominal voltages from 35 kV to 245 kV, ensure that individual harmonic voltages, measured as ten-minute mean values, do not exceed the following values:

TABLE B.2 LIMIT VALUES FOR HARMONIC VOLTAGES FOR HV AND EHV ≤ 245 KVV

Odd harmonics				Even harmonics	
Not multiple of 3		Multiple of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5	3.0 %	3	3.0 %	2	1.5 %
7, 11	2.5 %	9	1.5 %	4	1.0 %
13, 17	2.0 %	15, 21	0.5 %	6	0.5 %
19, 23	1.5 %	>21	0.3 %	>6	0.3 %
25	1.0 %				
>25	0.5 %				

- THD: 100% of the time ≤ 3% (10-min mean values)
  - EHV above 245 kV: The TSO shall, in connection points with nominal voltages above 245 kV, ensure that individual harmonic voltages, measured as ten-minute mean values, do not exceed the following values:

TABLE B.3 LIMIT VALUES FOR HARMONIC VOLTAGES FOR EHV >245 KV

Odd harmonics				Even harmonics	
Not multiple of 3		Multiple of 3			
Order h	U_h	Order h	U_h	Order h	U_h
5, 7	2.0 %	3	2.0 %	2	1.0 %
11, 13, 17, 19	1.5 %	9	1.0 %	4, 6	0.5 %
23, 25	1.0 %	15, 21	0.5 %	>6	0.3 %
>25	0.5 %	>21	0.3 %		

THD: 100% of the time ≤ 2% (10-min mean values)

- 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:
  - $\Delta U_{steady\ state}$ ≥ 3%:
  - max [#]: 24 for 0.23 ≤ U_N ≤ 35 [kV]
  - max [#]: 12 for 35 < U_N [kV]
  - ΔU_{max}: ≥ 5%:
  - max [#]: 24 for 0.23 ≤ U_N ≤ 35 [kV]
  - max [#]:12 for 35 < U_N [kV]

Portugal

- Supply voltage variations (EHV): For EHV 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 (EHV): For EHV the Quality of Service Code establishes that under normal operating conditions, in any period of 1 week the long (P_{lt}) and the short (P_{st}) term flicker severity caused by voltage fluctuation should be lower than 1.
- Voltage dips (EHV): Limits are not established
- Voltage unbalance (EHV): Under normal operating conditions, during each period of 1 week, 95% of the 10 min mean r.m.s. values of the negative sequence of the supply voltage shall be less or equal than 2% of the direct sequence voltage.
- Harmonic voltage (EHV): For EHV, 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: 3.0
  - h=3: 2.0
  - h=2: 1.5
  - h=7: 2.0
  - h=9: 1.0
  - h=4: 1.0
  - h=11: 1.5
  - h=15: 0.3
  - h=6: 0.5
  - h=13: 1.5
  - h=21: 0.2
  - h=8: 0.4
  - h=17: 1.0
  - h=>21: 0.2
  - h=10: 0.4
  - h=19: 1.0
  - h=12: 0.2
  - h=23: 0.7
  - h=>12: 0.2
  - h=25: 0.7
  - h>25: 0.2+12.5/h
- THD=<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 3 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 3 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.
  - HV: 100% of time. Limits for harmonics not multiple of 3 of order higher than 13 are already in place.
  - MV and LV: 100% of time.
- Single rapid voltage change (HV, MV, LV): A maximum number of voltage changes are allowed.

The Netherlands

- Power frequency – interconnected areas (HV, MV, LV): 50 Hz +/- 1% during 99.9% of the year, 50 Hz + 2% / - 4% all the year

- Supply voltage variations (EHV, HV, MV, LV):
  - EHV and HV: Uc +/- 10% for 99.9% of 10 minute averaged values during a week
  - MV and LV: Uc +/- 10% for 95% of 10 minute averaged values during a week; Uc +10%/-15% for all 10-minute averaged value

- Flicker (EHV, HV, MV, LV):
  - EHV and HV
    - ≤10%Uc
    - ≤3%Uc in case there is no loss of production, large consumers or connections
    - P_{lt}≤1 during 95% of a week, using 10 minute averages
    - P_{lt}≤5 during 100% of a week, using 10 minute averages
  - MV and LV
    - ≤10%Uc
    - ≤3%Uc in case there is no loss of production, large consumers or connections
    - P_{lt}≤1 during 95% of a week, using 10 minute averages

- Voltage dips (EHV, HV, MV): The limit for voltage dips in EHV and HV depends on the dip duration and the retained voltage. Limits for voltage dips in the MV-network are currently under development.

- Voltage unbalance (EHV, HV, MV, LV):
  - EHV and HV: The inverse component of the voltage should be ≤1% of the normal component, during 99.9% of the 10 minute averaged values during a week.
  - MV and LV: The inverse component of the voltage should be in between 0 and 2% of the normal component, during 95% of the 10 minute measurements per week. The inverse component of the voltage should be in between 0 and 3% of the normal component for all measurements

- Harmonic voltage (EHV, HV, MV, LV):
  - EHV
    - THD ≤ 5% for all harmonics (until 40^{th}) during 95% of the 10 minute averaged values during a week.
    - THD ≤ 6% for all harmonics (until 40^{th}) during 99.9% of the 10 minute averaged values during a week.
  - HV
    - THD ≤ 6% for all harmonics (until 40^{th}) during 95% of the 10 minute averaged values during a week.
    - THD ≤ 7% for all harmonics (until 40^{th}) during 99.9% of the 10 minute averaged values during a week.
  - MV
    - THD ≤ 8% for all harmonics (until 40^{th}) during 95% of the 10 minute averaged values during a week.
    - THD ≤ 12% for all harmonics (until 40^{th}) during 99.9% of the 10 minute averaged values during a week.

Part 2 – Voltage Quality Data

This Annex provides an overview of the voltage dip characteristics and actual voltage quality data that countries have provided in response to the questionnaire for this report. The responding countries for this Annex include France, Portugal and Slovenia.

7.7.1 Voltage dips classification

Dip characteristic

The dip characteristics are calculated from the sampled voltage waveform. The resulting characteristics and indicators 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 [31]:
- On LV networks, for 4-wire 3-phase systems, the line-to-neutral voltages shall be considered;
- On LV networks, for 3-wire 3-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 [32] are along the same lines.

Once the appropriate voltages have been sampled, the dip characteristics can be determined. The standard EN 61000-4-30 defines 2 characteristics [33]:
- The residual voltage is the lowest r.m.s. voltage 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.

7.7.2 Site incidents

From the voltage dips recorded at 1 location over a period of typically 1 year, site indicators can be calculated. These are typically the number of voltage dips with characteristics within a certain range.

TABLE B.4 CLASSIFICATION OF VOLTAGE DIPS ACCORDING TO THE STANDARD EN 50160

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	CELL A1	CELL A2	CELL A3	CELL A4	CELL A5
80 > u ≥ 70	CELL B1	CELL B2	CELL B3	CELL B4	CELL B5
70 > u ≥ 40	CELL C1	CELL C2	CELL C3	CELL C4	CELL C5
40 > u ≥ 5	CELL D1	CELL D2	CELL D3	CELL D4	CELL D5
5 > u	CELL X1	CELL X2	CELL X3	CELL X4	CELL X5

For each of the cells in Table B-4 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 1, 2 and 3 phases); and time aggregation (any difference in treatment for multiple dips based on the time elapsed between these events).*

System indicators

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

According to the recommendations given in CIGRE TB 412 [32] a number of percentile values should be used, for example the 25%, 50%, 75%, 90% and 95% values.

France

TABLE B.5 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS 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	1.6	0.73	0.11	
80 > u ≥ 70	5.4	0.38	0.23	0.05	
70 > u ≥ 40	3.3	0.33	0.27	0.15	
40 > u ≥ 5	0.41	0.14	0.06	0	
5 > u					

TABLE B.6 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE TRANSMISSION NETWORKS IN FRANCE IN 2011

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	26	2	0.91	0.25	
80 > u ≥ 70	6.4	0.38	0.31	0.07	
70 > u ≥ 40	3.6	0.37	0.32	0.16	
40 > u ≥ 5	0.48	0.23	0.09	0.04	
5 > u					

TABLE B.7 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE TRANSMISSION NETWORKS IN FRANCE IN 2012

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	25	1.1	0.52	0.35	
80 > u ≥ 70	5.9	0.39	0.17	0.04	
70 > u ≥ 40	3.2	0.35	0.18	0.16	
40 > u ≥ 5	0.55	0.13	0.07	0.04	
5 > u					

TABLE B.8 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE TRANSMISSION NETWORKS IN FRANCE IN 2013

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	30	1.6	0.65	0.15	
80 > u ≥ 70	7.4	0.29	0.27	0.03	
70 > u ≥ 40	4.9	0.48	0.12	0.21	
40 > u ≥ 5	0.75	0.23	0.07	0.06	
5 > u					

TABLE B.9 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE TRANSMISSION NETWORKS IN FRANCE IN 2014

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	30	1.5	0.56	0.06	
80 > u ≥ 70	6.9	0.34	0.21	0.04	
70 > u ≥ 40	3.6	0.33	0.17	0.14	
40 > u ≥ 5	0.45	0.15	0.07	0.05	
5 > u					

Norway

TABLE B.10 NUMBER OF VOLTAGE DIPS (1) PER NUMBER OF MONITORED POINTS IN THE DISTRIBUTION NETWORKS IN NORWAY IN 2014

Residual Voltage *u* [%]	Duration *t* [ms] (2)				
	10 < t ≤ 200	200 < t ≤ 500	500 < t ≤ 1,000	1,000 < t ≤ 5,000	5,000 < t ≤ 60,000
90 > u ≥ 80	8.00	5.53	1.29	0.21	1.16
80 > u ≥ 70	4.54	3.58	1.39	0.12	1.12
70 > u ≥ 40	1.80	1.47	1.14	0.08	0.66
40 > u ≥ 5	0.51	0.45	0.76	0.05	0.69
5 > u	0.42	0.30	0.60	0.14	0.11

(1) "Beta-version" after first reporting of voltage quality.
(2) The duration intervals differ from the intervals given in the voltage dip classification table in EN 50160.

Portugal

The data presented in the tables for dips and swells refers to the number of voltage events by the number of monitored points of the network. For the TSO, in 2014, data from 32 delivery points were considered, measured in the HV busbars of the EHV/HV substations. For the DSO, in 2014, data from 70 delivery points were considered, measured in the MV busbars of the HV/MV substations.

TABLE B.11 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE DISTRIBUTION NETWORKS IN PORTUGAL IN 2014

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	46.97	6.26	6.74	1.15	0.11
80 > u ≥ 70	14.64	2.25	3.07	0.24	0.03
70 > u ≥ 40	13.23	3.62	3.29	0.65	
40 > u ≥ 5	4.37	2.58	0.80	0.20	
5 > u	0.06	0.03		0.05	0.02

TABLE B.12 NUMBER OF VOLTAGE DIPS PER NUMBER OF MONITORED POINTS IN THE TRANSMISSION NETWORKS IN PORTUGAL IN 2014

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	40.97	1.5	0.81	0.63	
80 > u ≥ 70	12.06	0.59	0.34	0.16	
70 > u ≥ 40	11.59	0.72	0.13	0.31	
40 > u ≥ 5	1.97	0.31	0.09	0.09	
5 > u	0.03				

Slovenia

The data represent only the DSO level. The data for the TSO level are unavailable.

TABLE B.13 NUMBER OF VOLTAGE DIPS IN THE DISTRIBUTION NETWORKS IN SLOVENIA IN 2014

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	21,211	1,207	712	389	120
80 > u ≥ 70	8,103	471	218	279	35
70 > u ≥ 40	9,142	821	319	149	17
40 > u ≥ 5	3,489	1,808	144	70	15
5 > u	1,053	853	182	67	813

Part 3 – Main Work of the European Energy Regulators on Voltage Quality

TABLE B.14 MAIN WORK OF THE EUROPEAN ENERGY REGULATORS ON VOLTAGE

Title of the report or description of the activity	Year	Reference
3rd Benchmarking Report on Quality of Electricity Supply	2005	C05-QOS-01-03
CEER cooperation with CENELEC on	2006	EN 50160:2010
'Voltage characteristics of electricity supplied by public electricity networks'		
Public Consultation Paper 'Towards Voltage Quality Regulation in Europe'	2006	E06-EQS-09-03
Conclusions Paper 'Towards Voltage Quality Regulation in Europe' (and evaluation of comments paper)	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	2008	C08-EQS-24-04
Round table "CEER/Eurelectric cooperation on continuity of supply and voltage quality requirements and incentives"	2009	RT.2b @ CIRED 2009
CEER-Eurelectric workshop on voltage quality monitoring	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"	2010	C10-EQS-41-03 TR F6978
Final Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas	2011	E10-RMF-29-05
CEER-Eurelectric Round Table "Voltage quality monitoring, dip classification and responsibility sharing"	2011	RT.2a @ CIRED 2011
5th Benchmarking Report on Quality of Electricity Supply 2011	2012	-
CEER-ECRB, "Guidelines of Good Practice on the Implementation and Use of Voltage Quality Monitoring Systems for Regulatory Purposes"	2012	C12-EQS-51-03
CEER Benchmarking Report 5.1 on the continuity of electricity supply	2014	C13-EQS-57-03
CEER Benchmarking Report 5.2 on the continuity of electricity supply	**2015**	C14-EQS-62-03

ANNEX C
GAS – TECHNICAL OPERATIONAL QUALITY

TABLE C.1 LENGTH OF PIPES

Country	Year	Length of transmission network (in km)	Length of distribution network (in km)	Length of high pressure network (in km)	Length of medium pressure network (in km)	Length of low pressure network (in km)
Austria	2010	33,027	6,829	33,027	3,685	3,143
	2011	33,594	6,793	33,594	3,685	3,108
	2012	34,044	6,884	34,044	3,674	3,210
	2013	34,476	7,100	34,476	3,990	3,109
	2014	34,758	7,169	34,758	4,041	3,129
Belgium	2010	4,037	64,438	3,565	472,000	50,422
	2011	4,097	64,868	3,628	469,000	51,596
	2012	4,060	66,232	3,596	464,000	52,688
	2013	4,056	67,197	3,593	463,000	53,472
	2014	4,023	71,220	3,573	450,000	56,465
Croatia	2010	2,289	18,044			
	2011	2,511	18,123			
	2012	2,530	18,368	3,771	13,957	3,170
	2013	2,662	18,576	3,900	13,988	3,351
	2014	2,694	19,313	3,946	14,874	3,187
Czech Republic	2010					
	2011	3,652	61,018	12,951	36,889	11,178
	2012	3,810	61,281	13,022	37,392	10,861
	2013	3,816	61,348	13,006	37,543	10,791
	2014	3,821	61,415	12,986	37,729	10,699
Estonia	2010					
	2011	878,000	2,085			
	2012	878,000	2,097			
	2013	885,000	2,108			
	2014	885,000	2,118			
Finland	2010	1,188	1,878			
	2011	1,314	1,931			
	2012	1,315	1,963			
	2013	1,287	1,984			
	2014	1,287	1,986			
France	2010		192,144		185,177	10,983
	2011	8,260	193,340	4,244	186,617	10,739
	2012	8,340	194,601	4,313	188,211	10,417
	2013	8,380	195,851	4,352	189,721	10,158
	2014	8,390	196,940	4,362	190,991	9,977
Germany	2010	46,829	448,964	117,135	225,835	152,435
	2011	39,495	471,213	157,300	224,880	128,528
	2012	37,695	470,433	130,547	223,076	154,505
	2013	37,880	485,413	132,058	231,624	159,611
	2014	37,580	481,103	129,793	231,603	157,287
Hungary	2010	5,577	82,619	5,577		
	2011	5,785	82,997	5,785		
	2012	5,784	83,092	5,784		
	2013	5,782	83,222	5,782		
	2014	5,782	83,530	5,782		
Ireland	2010	2,143	10,911			
	2011	2,149	11,074			
	2012	2,149	11,076			
	2013	2,149	11,160			
	2014	2,213	11,221			

Country		Length of transmission network (in km)	Length of distribution network (in km)	Length of high pressure network (in km)	Length of medium pressure network (in km)	Length of low pressure network (in km)
Italy	2010	33,768	250,041	35,526	102,353	145,930
	2011	34,135	248,648	36,110	100,780	145,893
	2012	34,415	252,266	36,196	103,915	146,571
	2013	34,510	253,581	362,146	103,690	148,187
	2014	34,628	256,410	36,367	105,331	149,340
Latvia	2010					
	2011					
	2012					
	2013					
	2014	1,242	5,516	851,000	2,518	2,147
Lithuania	2010	1,062	8,053			
	2011	1,062	8,090	2,341	3,939	3,679
	2012	1,098	8,206	2,389	4,021	3,700
	2013	1,201	8,337	2,505	4,111	3,728
	2014	1,201	8,473	2,508	4,208	3,764
Poland	2010	9,753	148,224			
	2011	10,537	150,800			
	2012	10,718	171,786			
	2013	10,761	161,655			
	2014	11,007	178,487			
Portugal	2010	1,267	14,840	1,267		
	2011	1,296	15,433	1,296		
	2012	1,298	15,878	1,298		
	2013	1,375	16,291	1,375		
	2014	1,375	17,374	1,375	1,192	16,182
Slovenia	2010	1,018	4,163	2,427	635,000	2,119
	2011	1,054	4,305	2,541	644,000	2,157
	2012	1,094	4,343	2,593	676,000	2,168
	2013	1,121	4,449	2,676	683,000	2,211
	2014	1,155	4,532	2,748	691,000	2,248
Spain	2010	11,665	62,535			
	2011	11,731	64,672			
	2012	12,815	67,282			
	2013	13,492	67,696			
	2014	13,716	68,090			
Sweden	2010	620,000	2,716			
	2011	620,000	2,708			
	2012	620,000	2,854			
	2013	601,000	2,857			
	2014	601,000	2,882			

TABLE C.2 LNUMBER OF SERVED CUSTOMERS

Country	Year	Number of served customers in total	High pressure customers	Medium pressure customers	Low pressure customers	Other Type 1	Other Type 2	Other Type 3
Austria	2010							
	2011	1,350,842						
	2012	1,350,310						
	2013	1,350,423						
	2014	1,348,958						
Belgium	2010		162,000	96,000				
	2011		165,000	90,000				
	2012		160,000	91,000				
	2013		160,000	86,000				
	2014		157,000	85,000	3,092,271			
Croatia	2010	633,477						
	2011	643,618						
	2012	646,971						
	2013	651,099						
	2014	649,674						
Czech Republic	2010	2,870,634	1,742	7,021	198,449	2,663,422 (a)		
	2011	2,869,023	1,707	7,033	200,496	2,659,787		
	2012	2,868,083	1,652	6,939	202,807	2,656,685		
	2013	2,860,345	1,637	6,946	201,274	2,650,488		
	2014	2,849,162	1,599	6,841	197,824	2,642,898		
Estonia	2010							
	2011	50,221						
	2012	50,261						
	2013	50,485						
	2014	51,166						
Finland	2010	38,150						
	2011	38,009						
	2012	38,111						
	2013	38,101						
	2014	38,049						
France	2010	11,000,000						
	2011	11,000,000	1,000					
	2012	11,000,000	991,000					
	2013	11,000,000	951,000					
	2014	11,000,000	972,000					
Germany	2010	13,503,145						
	2011	13,419,509						
	2012	13,698,780						
	2013	13,979,337						
	2014	13,837,257						
Hungary	2010	3,533,688	35,000		3,533,653			
	2011	3,540,204	35,000		3,540,169			
	2012	3,514,896	35,000		3,514,861			
	2013	354,696	35,000		3,467,661			
	2014	3,644,693	35,000		3,644,658			
Ireland	2010	643,831						
	2011	656,595						
	2012	661,890						
	2013	666,903						
	2014	673,160						

Country	Year	Number of served customers in total	High pressure customers	Medium pressure customers	Low pressure customers	Other Type 1	Other Type 2	Other Type 3
Italy	2010	21,120,814						
	2011	21,237,748						
	2012	21,358,817						
	2013	21,565,608						
	2014	21,689,304						
Latvia	2010							
	2011							
	2012							
	2013							
	2014	443,402						
Lithuania	2010							
	2011							
	2012							
	2013	561,561						
	2014	565,114						
The Netherlands	2010			10,606	7,119,659	7,127,369 (d)	10,606 (f)	7,119,659 (g)
	2011			10,465	7,117,140	7,125,418	10,465	7,117,140
	2012			10,567	7,167,606	7,178,173	10,567	7,167,606
	2013			9,798	7,184,303	7,194,101	9,798	7,184,303
	2014			9,978	721,705	7,227,035	9,978	7,217,057
Poland	2010	6,624,884						
	2011	6,747,364						
	2012	6,806,773						
	2013	6,806,773						
	2014	6,868,294						
Portugal	2010							
	2011							
	2012							
	2013	1,320,052	22,000	393,000	1,319,637	1,299,251 (b)	37,293 (e)	
	2014	1,355,122	22,000	399,000	1,354,701	1,333,437	39,765	
Slovenia	2010	128,769						
	2011	130,293						
	2012	131,652						
	2013	132,939						
	2014	133,230						
Spain	2010	7,180,332	121,000	3,930	7,175,681	600 (c)		
	2011	7,278,501	114,000	3,949	7,273,873	565,000		
	2012	7,366,468	113,000	3,877	7,361,856	622,000		
	2013	7,448,855	118,000	4,133	7,443,893	711,000		
	2014	7,548,654	116,000	3,967	7,543,729	842,000		
Sweden	2010	40,058						
	2011	39,659						
	2012	37,704						
	2013	37,393						
	2014	37,023						

(a) Households.
(b) Domestic.
(c) Single Customers Supplied By A LNG Satellite Plants.
(d) Total (DSO's).
(e) Non-Domestic.
(f) P > 200 mbar (DSO's).
(g) P ≤ 200 mbar (DSO's).

ANNEX D
GAS – NATURAL GAS QUALITY

TABLE D.1 OXYGEN (O_2) MAXIMUM VALUE

Oxygen (O_2)	Max	Unit	Measurement frequency	Publication frequency
Belgium	0.1	Ppm	In real time	Hourly
Croatia	0.001	% mol	Twice per month	Twice per month
Czech Republic	0.020	% mol	In real time	Monthly
Estonia	0.010	% mol	5 minutes	Monthly
France	0.010	% mol	5 minutes	Not published
Great Britain	0.200	% mol		
Hungary	0.200	% mol	Occasionally	Occasionally
Ireland	0.200	% mol	Monthly	Yearly
Italy	0.600	% mol	Quarterly	
Latvia	0.020	% mol	In real time	Monthly
Lithuania	0.5 (1)	% mol	In real time	Not published
	0.02 (2)			
Poland	0.200	% mol		
Portugal		% mol	In real time	Monthly
Spain	0.010	% mol	Daily	
CEN	**0.001 or 1** (3)	**% mol**		

(1) If the pressure P < 1.6 MPa.
(2) If the pressure P ≥ 1.6 MPa.
(3) At network entry points and interconnection points the mole fraction of oxygen shall be no more than 0.001 %, expressed as a moving 24 hour average. However, where the gas can be demonstrated not to flow to installations sensitive to higher levels of oxygen, e.g. underground storage systems, a higher limit of up to 1 % may be applied.

TABLE D.2 CARBON DIOXIDE (CO_2) MAXIMUM VALUE

Carbon Dioxide (CO_2)	Max	Unit	Measurement frequency	Publication frequency
Belgium	2.5	% mol	5 minutes	Not published
Croatia	2.5	% mol	Twice per month	Twice per month
Czech Republic	3.0	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	2.5	% mol	5 minutes	Not published
Hungary	No limit	% mol	4 minutes	Daily
Ireland	2.5	% mol	Monthly	Yearly
Italy	3.0	% mol	Hourly	Monthly
Latvia	2.5	% mol	In real time	Monthly
Lithuania		% mol	In real time	Monthly
The Netherlands	2.5	% mol		
Poland	3.0	% mol	In real time	Monthly
Portugal		% mol	In real time	Monthly
Slovenia	2.5	% mol	Hourly	Daily
Spain	2.5	% mol	Daily	NA
CEN	**2.5 or 4** (1)	**% mol**		

(1) At network entry points and interconnection points the mole fraction of carbon dioxide shall be no more than 2.5%. However, where the gas can be demonstrated not to flow to installations sensitive to higher levels of carbon dioxide, e.g. underground storage systems, a higher limit of up to 4 % may be applied.

TABLE D.3 METHANE (CH_4) MINIMUM VALUE

Methane (CH_4)	Min	Unit	Measurement frequency	Publication frequency
Croatia	85.0	% mol	Twice per month	Twice per month
Czech Republic	85.0	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	91.1	% mol	5 minutes	Daily
Hungary	No limit	% mol	4 minutes	Daily
Ireland		% mol	Monthly	Yearly
Italy		% mol	Hourly	Monthly
Latvia	90.0	% mol	In real time	Monthly
Lithuania	90.0	% mol	In real time	Monthly
Poland	92.0	% mol	In real time	Monthly
Portugal		% mol	In real time	Monthly
Slovenia		% mol	Hourly	Daily
Spain	No limit, except for biogas 95.0	% mol	NA	NA
CEN	**65.0**	**% mol**		

TABLE D.4 ETHANE (C_2H_6) MAXIMUM VALUE

Ethane (C_2H_6)	Min	Unit	Measurement frequency	Publication frequency
Croatia	7.00	% mol	Twice per month	Twice per month
Czech Republic	7.00	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	6.10	% mol	5 minutes	Daily
Hungary	No limit	% mol	4 minutes	Daily
Ireland	12.00	% mol	Monthly	Yearly
Italy		% mol	Hourly	Monthly
Latvia	8.00	% mol	In real time	Monthly
Lithuania		% mol	In real time	Monthly
Poland	4.00	% mol	In real time	Monthly
Slovenia		% mol	Hourly	Daily

TABLE D.5 PROPANE (C_3H_8) MAXIMUM VALUE

Propane (C_3H_8)	Min	Unit	Measurement frequency	Publication frequency
Croatia	6.00	% mol	Twice per month	Twice per month
Czech Republic	3.00	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	1.03	% mol	5 minutes	Daily
Hungary	No limit	% mol	4 minutes	Daily
Ireland		% mol	Monthly	Yearly
Italy		% mol	Hourly	Monthly
Latvia	3.00	% mol	In real time	Monthly
Lithuania	3.00	% mol	In real time	Monthly
Poland		% mol	In real time	Monthly
Slovenia		% mol	Hourly	Daily

TABLE D.6 NITROGEN (N_2) MAXIMUM VALUE

Nitrogen (N_2)	Min	Unit	Measurement frequency	Publication frequency
Croatia	3.00	% mol	Twice per month	Twice per month
Czech Republic	5.00	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	1.59	% mol	5 minutes	Daily
Hungary	No llimit	% mol	4 minutes	Daily
Ireland	5.00	% mol	Monthly	Yearly
Italy			Hourly	Monthly
Latvia	3.00	% mol	In real time	Monthly
Lithuania	5.00	% mol	In real time	Monthly
Poland	2.00	% mol	In real time	Monthly
Slovenia			Hourly	Daily

TABLE D.7 SUM OF BUTANES MAXIMUM VALUE

Sum of Butanes	Max	Unit	Measurement frequency	Publication frequency
Czech Republic	2.00	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	0.26	% mol	5 minutes	Daily
Hungary	No limit	% mol	4 minutes	Daily
Ireland		% mol	Monthly	Yearly
Italy		% mol	Hourly	Monthly
Latvia	1.00	% mol	In real time	Monthly
Lithuania	1.00	% mol	In real time	Monthly
Poland		% mol	In real time	Monthly
Slovenia		% mol	Hourly	Daily

TABLE D.8 SUM OF PENTANES AND HIGHER HYDROCARBONS MAXIMUM VALUE

Sum of Pentanes and Higher Hydrocarbons	Max	Unit	Measurement frequency	Publication frequency
Czech Republic	0.50	% mol	In real time	Monthly
Estonia	No limit	% mol	5 minutes	Monthly
France	0.03	% mol	5 minutes	Daily
Hungary	No limit	% mol	4 minutes	Daily
Ireland			Monthly	Yearly
Italy		% mol	Hourly	Monthly
Latvia			In real time	Monthly, 10 days
Lithuania			In real time	Monthly
Poland	2.00	% mol	In real time	Monthly
Slovenia			Hourly	Daily

TABLE D.9 DELIVERY TEMPERATURE VALUES

Delivery Temperature	Min	Max	Unit	Measurement frequency	Publication frequency
Belgium	2.0	38.0	°C	In real time	Hourly
Estonia	0.0	50.0	°C		
France	-30.0	50.0	°C	5 minutes	Not published
Hungary	0.0		°C	In real time	Daily
Latvia			°C	In real time	Not published
Lithuania			°C	In real time	Not published
The Netherlands	10.0	30.0	°C		
Poland	0.0	50.0	°C	In real time	Not published
Slovenia		42.0	°C	In real time	

TABLE D.10 DUST PARTICLES MAXIMUM VALUES

Dust Particles	Max	Unit	Measurement frequency	Publication frequency
France	5.0	mg/m³	Not measured	Not measured
Hungary	5.0	mg/m³	Occasionally	Occasionally
Latvia	0.001	g/m³	10 days	Monthly, 10 days
Lithuania	0.001		Monthly	Not published
The Netherlands	100.0	mg/m³		
Poland	1.0	mg/m³	In real time	Monthly
Spain	Technically pure			

TABLE D.11 HYDROGEN (H_2) MAXIMUM VALUE

Hydrogen (H_2)	Max	Unit	Measurement frequency	Publication frequency
France	6.00	% mol	5 minutes	Not published
Great Britain	0.1	% mol		
Ireland	0.10	% mol	Monthly	Yearly
Lithuania	2.00 (1)	% mol	Twice per year	Not published
The Netherlands	0.02	% mol		
Spain	No limit, except for biogas: 5.00	% mol		

(1) If P < 1.6 MPa not allowed if P ≥ 1.6 MPa.

TABLE D.12 WATER (H_2O) MAXIMUM VALUE

Water (H_2O)	Min	Max	Unit	Measurement frequency	Publication frequency
France	83.0	99.0	mg/m³	5 minutes	Daily
Hungary		170.0	mg/m³	10 minutes	Daily
Lithuania	Not allowed			Monthly	Not published

TABLE D.13 CARBON MONOXYDE (CO) MAXIMUM VALUE

Carbon Monoxyde (CO)	Max	Unit	Measurement frequency	Publication frequency
France	2.0	% mol	5 minutes	Not published
Great Britain	0.48	% mol		
The Netherlands	2.9	% mol		

TABLE D.14 INCOMPLETE COMBUSTION FACTOR MAXIMUM VALUE

Incomplete Combustion Factor	Max	Unit	Measurement frequency	Publication frequency
Ireland	0.48	%	Monthly	Yearly
Slovenia			Hourly	

TABLE D.15 SOOT INDEX MAXIMUM VALUE

Soot Index	Max	Unit	Measurement frequency	Publication frequency
Great Britain	0.6	%		
Ireland	0.6	%	Monthly	Yearly
Slovenia			Hourly	

TABLE D.16 THT (C_4H_8S) VALUES

THT (C_4H_8S)	Min	Max	Unit	Measurement frequency	Publication frequency
France	15.0	40.0	mg/m^3	5 minutes	5 minutes

ANNEX ON THE 6TH CEER BENCHMARKING REPORT – QUALITY OF ELECTRICITY SUPPLY IN THE ENERGY COMMUNITY[1]

1. Approved by the ECRB Board in May 2016.

1 INTRODUCTION

1.1. ABOUT ECRB

The **Energy Community**[2] comprises Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Kosovo*[3], Moldova, Montenegro, Serbia and Ukraine. Armenia, Georgia, Turkey and Norway are Observer Countries. The key aim of the organization is to extend the EU internal energy market to South East Europe and beyond on the basis of a legally binding framework.

The Energy Community Regulatory Board (ECRB) operates based on the Energy Community Treaty. As an institution of the Energy Community ECRB advises the Energy Community Ministerial Council and Permanent High Level Group on details of statutory, technical and regulatory rules and makes recommendations in the case of cross-border disputes between regulators.

ECRB is the independent regional voice of energy regulators in the Energy Community. ECRB's mission builds on three pillars: providing coordinated regulatory positions to energy policy debates, harmonizing regulatory rules across borders and sharing regulatory knowledge and experience.

1.2. BACKGROUND AND SCOPE

Quality of electricity supply as a topic was introduced into the ECRB Work Program already in 2008; the first ECRB "Report on Quality of Electricity Service Standards and Incentives in Quality Regulation" was published in 2009. Also, during 2009 and 2010, the ECRB organized two workshops which were followed by the report "Assistance to regulators in introducing and improving service quality regulation in the Energy Community", published in 2010.

In 2011 ECRB members participated in the 5th CEER Quality of Supply Benchmarking Report to which the analysis for the ECRB member countries – performed based on the CEER benchmarking indicators – was added as an annex.

Following the well established ECRB-CEER cooperation tradition on the very topic, the present benchmarking report represents an annex to the "6th CEER Benchmarking Report[4] on Quality of Electricity Supply", covering the Energy Community Contracting Parties (CPs) **Albania, Bosnia and Herzegovina, FYR Macedonia, Kosovo*,**[5] **Montenegro, Serbia and Ukraine**.

This report covers all **three aspects of quality of electricity supply**, namely:

- Continuity of Supply (CoS),
- Voltage Quality (VQ) and
- Commercial Quality (CQ).

In general, the present report aims to present an overview and analysis of current practices in the CPs. It also provides an assessment of areas where a move towards harmonisation could further improve quality of supply. The findings and recommendations of the report will hopefully lead to further development of national regulation and harmonization among the CPs.

Chapter 2 of the report deals with continuity of supply related to the availability of electricity. It provides an overview of the existing quality of service regulation frameworks of continuity of supply applied in the CPs. Analyses in this chapter 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.

2. www.energy-community.org.
3. Throughout this document the symbol * refers to the following statement: This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Advisory Opinion on the Kosovo declaration of independence.
4. The Council of European Energy Regulators (CEER) prepares a Benchmarking Report on the Quality of Electricity Supply every few years. The first report was issued in 2001, followed by the second, third and fourth editions in 2003, 2005, 2008 and 2011. These five benchmarking reports, published up to now, present an overview and analysis of practices in the CEER countries related to quality of electricity supply.
5. This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.

Chapter 3 is dedicated to voltage quality. In simple terms, voltage quality deals with deviations from nominal values of voltage frequency and voltage magnitude and by distortions. This chapter provides an overview of existing practice in voltage quality monitoring and regulation in transmission and distribution of electricity in the CPs and covers VQ regulation and legislation, voltage quality monitoring system (VQMS), data collection, aggregation and publication from VQMS, VQ indicators, actual data for voltage dips, other VQ parameters, mitigation measures and studies on estimation of costs due to poor voltage quality.

Chapter 4 focuses on commercial quality, which relates to the nature and quality of customer services provided to end-consumers of electricity. Commercial quality is directly associated with transactions between electricity companies (either DSOs or suppliers, or both) and customers. Commercial quality covers not only the supply and sale of electricity, but also various forms of contacts between electricity companies and customers. The questionnaires on commercial quality were divided in the following groups: connection related activities, customer care, technical service, metering and billing. Therefore, this chapter also follows that grouping.

1.3. METHODOLOGY

The analysis for the Energy Community is based on indicators used by CEER for its benchmarking analysis. To this extent the assessment for the CPs bases on the same definitions and theoretical background as defined for the EU Member States, in particular with a view to ensure comparability.

1.4. ACKNOWLEDGEMENTS

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 Contracting Parties for participating in the present analysis. In this context special thanks are also addressed to Mr Srdjan Žutobradić, Mrs Milodarka Dautović and Mr Nikola Dubajić for their effort in preparing this survey. At the same time ECRB also expresses its appreciation for the support received from the EU regulators on CEER level.

2 CONTINUITY OF SUPPLY

2.1. INTRODUCTION

This chapter provides an overview of the existing quality service regulation frameworks of continuity of supply (CoS) applied in the Energy Community CPs.

This section will place a special focus on general experiences, experiences with the implementation processes and possible future improvements of the systems in place. Although there is some minor evidence on better developed regulation frameworks (by means of minimal standards on continuity of supply as well as the implementation of incentive schemes in particular CPs), **most of the observed CPs are in a very early stages of the development of service quality regulation**. The main focus within this chapter is therefore put on the characteristics of CoS monitoring schemes in distribution and transmission. The proper application of such schemes is the precondition for the future framework extensions.

For some rare cases with applied minimal standards on continuity of supply, as well as reward/penalty schemes, examples of existing regulatory practice in the area will be presented.

Review and analysis of collected data on continuity of supply show also the differences in timing and scope of CoS monitoring development among CPs. Consequently, countries were not able to provide the complete data set on different aspects of CoS monitoring and regulation expected from the questionnaire.

Continuity of supply is examined from different aspects and categorized into the following chapters:

- 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 presented in Table 1.

TABLE 1 INDICATION OF WHAT KIND OF INFORMATION ON CONTINUITY OF SUPPLY HAS BEEN PROVIDED BY DIFFERENT COUNTRIES

Country	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)
FYR of Macedonia	X		X			X (Partially)
Kosovo*	X		X			X (Partially)
Montenegro	X		X			X (Partially)
Serbia	X	X	X			X (Partially)
Ukraine	X	X				X (Partially)

It can be concluded from Table 1 that **most of the analyzed elements are not applicable due to an early stage of continuity of supply regulation implementation in all CPs**. The lack of data limits the scope of benchmarking of the actual levels and trends of continuity of supply among different CPs.

According to the current status of implementation, the following chapters mainly focus on an overview of the monitoring concepts, on the aspects and on the characteristics of 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 related 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 should be useful for NRAs 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:

- customer
- consumer
- (network) user

While the "network user" (or simply "user"), comprising both generator and consumer, is certainly the most appropriate term, different terms with the same meaning are used having in mind that there is no harmonized use of terms in place in the analyzed markets.

Also, different terminology is used when referring to the responsible party for continuity of supply. Although the Electricity Directive EC/72/2009 defines the terms transmission system operator and distribution system operator, or simply system operator, 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 using indicators and standards represents 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 monitoring of continuity of supply is performed in different ways – including different types of interruptions, different sets of indicators as well as different reporting detail. The following sections pinpoint the differences as well as concepts that are harmonized among the CPs. The harmonization, where existing, is not a result of legal enforcement but it has been implemented following examples of good practice in the EU[6].

An overview on monitoring techniques and results is presented in this section.

2.2.1. Types of interruptions monitored

All CPs use some sort of monitoring of interruptions as shown in Table 2. The focus of the CPs is mainly on long interruptions (duration > 3 minutes). The qualitative information on long interruptions is essential for calculation of continuity indicators that are widely used in regulation.

Three regulators declare to have access to the information regarding the number of short-term interruptions: short interruptions are monitored in the Ukraine, FYR Macedonia, and in a part of Bosnia and Herzegovina. In this context it is important to explain the way how short interruptions are currently monitored, especially due to the fact that SCADA is not yet fully implemented in the networks of CPs. The CPs that reported monitoring of short interruptions were additionally asked to provide brief information on the type of measurement method that is used, i.e. manual recording, usage of SCADA DMS, local substation logging, counter readings on reclosing devices or other methods.

In Bosnia and Herzegovina most of the distribution facilities do not have equipment for remote supervision and control installed (except facilities of one out of the five distribution companies which have SCADA system installed). 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 are consolidated in the main dispatching centers for the distribution network control. These data are subject to checks by the regulatory commission staff during monitoring activities.

Considering the general lack of SCADA, it can be concluded that **local substation logging and counter readings on reclosing relays are most commonly used practice for recording the interruptions**.

Unplanned long interruptions are monitored in all countries. However, not all countries monitor this type of interruptions at all voltage levels.

6. E.g. by adopting standards as EN 50160 and others.

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.

Bosnia and Herzegovina and FYR Macedonia have also accomplished to set some rules with limited scope (SCADA installed at certain voltage level or proprietary solutions by DSOs), the other CPs either have not set any rules yet or are planning to establish the rules and implement SCADA in the future.

Nearly half of the CPs has established some sort of standardized way for recording and reporting applied by means of dedicated application software or by the use of harmonized forms for data collection. This is usually a result of national regulations imposing obligations for 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 (DMS, GIS etc.).

TABLE 2 TYPES OF INTERRUPTIONS MONITORED

Country	Transient	Short	Long	Unplanned	Planned	Rules for automatic logging of interruptions (i.e. SCADA)	Standardized 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 Regulatory Commission.
FYR of Macedonia		X	X	X	X	SCADA comprising 110 kV substations that have possibility for remote records of interruptions.	DSO should keep records and report to ERC
Kosovo*			X	X	X	No (TSO has installed SCADA in 2011 and are able to record interruptions on HV also in some MV feeders	DSO should keep records for long interruptions(planed/unplanned) and report to ERO
Montenegro			X	X	X	SCADA for transmission	Yes, for long interruptions only
Serbia			X	X	X	No	Standardized form for recording and reporting of long interruptions is prescribed by the Information Rules issued by the NRA
Ukraine		X	X	X	X	No	Yes (approved by the NERC)

Definitions related the duration of long, short, and transient interruptions in different countries are shown in Table 3.

TABLE 3 DEFINITIONS OF LONG, SHORT AND TRANSIENT INTERRUPTIONS

Country	Transient	Short	Long
Albania	< 3 min	< 15 min	> 15 min
Bosnia and Herzegovina	Not defined	1 s < T ≤ 3min	> 3 min
FYR of Macedonia	Not defined	1.5 s < T ≤ 3 min	> 3 min
Kosovo*	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

Albanian definitions significantly differ from the rest of the countries as well as from definitions that can be found in standards (EN 50160) where the *unplanned interruption* ("accidental supply interruption") is classified as:

- *a long interruption* (>3 min),
- *a short interruption* (≤ 3 min).

The deviation in Ukraine, where an interruption lasting exactly three minutes is classified as *long interruption*, is minor and therefore not significant; the same can be concluded for Kosovo*, where the same type of interruptions (duration of exactly three minutes) are excluded from monitoring.

Furthermore, some minor differences in definitionscan be found also for the duration of *short interruptions*, especially at setting the lower limits: some definitions do not set lower bounds; some set the limit at 1.0 second or 1.5 seconds.

Albania is also the only CP that defines the type 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 of the definitions used for *unplanned and planned interruptions*, as well as rule on advance notice regarding the planned interruptions is given in Table 4. **The majority of CPs has set definitions for both *planned* and *unplanned interruptions* referring to the availability of advance notices to customers. Both types of interruptions are monitored accordingly.**

A *planned interruption* is defined in EN 50160 ("prearranged supply interruption") as an interruption for which customers are informed in advance, to allow the execution of scheduled works on the distribution system.

An *unplanned interruption* is defined in EN 50160 ("accidental supply interruption") as an interruption caused by permanent or transient faults, mostly related to the external events, equipment failures or interference.

Most CPs use similar definitions for *planned interruptions*. However, they do not refer to EN 50160 or any other references, such as 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 and Bosnia and Herzegovina.

All CPs have issued the rules on notice to customers affected, whereas the requirements for advance notice vary between 24 hours up to 10 days.

TABLE 4 DEFINITIONS OF PLANNED AND UNPLANNED INTERRUPTIONS

Country	Transient	Short	Long
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 ones. If the planned interruption lasts longer than it has been announced, the time above the planned is included in the non-planned interruptions which the operator is responsible for	Distributor is obliged to inform the end-users on the term and expected time of duration of the planned interruption, no later than 24h (RS)/48h (FBiH) 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 – in the mass media, in a clear and appropriate way
FYR of Macedonia	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	Timely in written form in case of singe customer affected, 24 hour in advance in case of group of customers affected
Kosovo*	An interruption notified in advance to all affected customers with adequate notice.	An interruption non notified in advance to all affected customers.	Where the TSO and 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 a national TV and suitable high-circulation daily national newspaper
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)	Yes. Minimum time-lag requested is at least 24h, notice by public media or in other 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	Yes, minimum time-lag requested is at least 24h, noticed by public media or in other adequate way
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	Yes 10 days for legal entities with repeated notice 1 day and 10 days for households

2.2.3. Voltage levels monitored

The incidents at different voltage levels are monitored in different CPs as shown in Table 5.

Incidents on MV and HV level are monitored in all CPs. Surprisingly, most of the CPs reported that they monitor interruptions on LV level (except Albania). The reliable recording of interruptions on LV level (interruption register) requires big investments in equipment for protection and remote supervision and control or call center functions, and it is not yet widely implemented in the EU Member States.

Efficient monitoring of interruptions for particular voltage levels covers the recording interruptions caused by incidents on own voltage level and by incidents on all higher voltage levels that affect the observed interruptions[7]. 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 on LV network (i.e. SCADA). The interruptions caused on LV that do not affect the protection system under supervision of SCADA installed on MV (or LV) or that are not reported by affected customers through the call centers, don't attribute to the MV statistics and consequently to the CoS indicators.

Only Ukraine, with monitoring on LV level established already in 2008, is on a good way to achieve comprehensive monitoring on all voltage levels.

TABLE 5 VOLTAGE LEVELS FOR WHICH MONITORING OF CONTINUITY TAKES PLACE

Country	LV	X	HV	EHV
Albania		X	X	
Bosnia and Herzegovina	See note	X	X	X
FYR of Macedonia	See note	X	X	
Kosovo*	See note	X	X	X
Montenegro	See note	X	X	
Serbia		X	X	X
Ukraine	X (1)	X	X	X

(1) Established since 2008; use of data from Call Centre IS + manual processing.

Notes:
The table represents the voltage level at 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 monitoring at 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 at lower voltage levels (i.e. 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 interruption's cause

An overview of the classification of interruption causes is given in Table 6. **Most CPs collect the information on the cause of interruptions.** Such information is very important for both the system operator and the regulator.

From the CPs' answers it can be concluded that **there is no harmonization related to classification of interruption causes.** It is also obvious that almost all CPs divide causes into separate categories. 5 CPs (all except Montenegro and Kosovo*) use the categories "third party" or "force majeure" (in a few cases with different designations).

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.

7. 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 6 CAUSE CATEGORIES USED WHEN RECORDING INTERRUPTIONS

Country	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
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 (MEPSO)	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
Kosovo*	Planned and unplanned interruptions.	All	Yes	Interruptions that result from system faults
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	

2.2.5. Exceptional events

Exceptional weather conditions and other exceptional circumstances can significantly affect the continuity of supply. Interruptions caused by exceptional events, even if quite rare, are usually very long and/or affect a substantial number of customers. The concept of exceptional events may reflect 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 among the CPs. According to the terminology used by the CEER, the term "exceptional events" will be used as a collective term in this section.

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 of the specific treatment in their national quality of supply regulations. In Serbia the information code regarding the classification of interruptions comprises the definition of force majeure.

The concepts of different kinds of exceptional events of other four countries are defined as described in Table 7 and can be grouped, despite of similar designation, as follows:

- extraordinary situations with significant impact on the continuity of supply (Bosnia and Herzegovina, Serbia and Ukraine);
- force majeure (FYR Macedonia, Serbia and Kosovo*[8]).

These situations can be classified based on their causes or on their impact on network performance.

8. An assumption since information on concept hasn't been provided!

TABLE 7 DEFINITIONS OF EXCEPTIONAL EVENTS

Country	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)
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)
Kosovo*	Force majeure	Yes. Events, circumstances or occurrences beyond the control of the system operator. The force majeure will be defined by the government for special cases.	Yes
Montenegro	Force majeure	Force Majeure are natural events that have the character of natural disasters (floods, earthquakes, fires, atmospheric discharges; winds, ice and snow that exceed projected technical standards established for a particular building/facility or equipment of an relevant operators, etc.) that could not be predicted, prevented, avoided or eliminated by taking measures that are applied in order to maintain safe and reliable operation of the power system, and which are determined on the basis of the report of the competent state authorities, as well as emergency and military actions and measures that have been introduced based on the decisions of the competent state authorities.	No
Serbia	Force majeure (1)	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 rockfalls, 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.

(1) Informational definition only.

No statistical methods defining "major event days" or "exceptional condition periods" (i.e. IEEE Std 1366-2003, Annex B) **exist. Also, there is no evidence of explicit regulations defining "exceptional events".**

The information collected from the CPs shows **a lack of harmonization which is probably caused by different concepts of national legislation on obligations and by inherent climate differences.** Therefore stringent harmonization might most probably not be feasible at all. The lack of harmonization as regards exceptional events affects the comparison of interruption data between the observed CPs significantly.

It is important to mention that Kosovo* excludes exceptional events from their statistics. In Bosnia and Herzegovina and FYR Macedonia such separate statistics (with/without exceptional events) are only provided upon request.

8. An assumption since information on concept hasn't been provided!

2.3. CONTINUITY OF SUPPLY INDICATORS

An overview on the definitions of different indices used for quantifying the number of interruptions is given in CEER's 5th Benchmarking Report on Quality of Electricity Supply (2011). The same definitions are used for the purpose of this report.

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 will provide information on the continuity of supply as seen by the customers – such a 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. It is obvious that a range of indicators is in use, 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 detail of the calculated indicator

Continuity of supply indicators can be calculated for a country or 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 such data for benchmarking DSOs, for setting the appropriate continuity standards according to regional or network characteristics, etc. DSO can use such data to make investment or maintenance decisions. The practice on calculation of system indicators varies strongly between different CPs, as shown in Table 8.

All CPs publish indicators calculated for the entire 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:** the reason is different level of data availability and non-harmonized types of causes among CPs. Four CPs provided separate indicators for rural and urban areas; one CP 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 three countries 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 formal definition by DSO as follows: city areas, outskirts, village areas (the indices are calculated aggregated only in Federation BiH);
- 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

Country	National	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)
FYR of Macedonia	X	X			X	X		X	X			
Kosovo*	X							X	X (planned/ unplanned only)			
Montenegro	X							X	X			
Serbia	X							X	X			
Ukraine	X	X		X				X	X	X		

2.3.2. Indices for long and short interruptions

An overview of the different indices used for quantifying long interruptions as well as weighting method used when calculating indices is provided in Table 9.

SAIDI and SAIFI are the most commonly-used indices for distribution networks. Serbia calculates also the index Customer Average Interruption Duration Index (CAIDI) which is a derivate of SAIDI in SAIFI. The method of weighting impacts the results by introducing different bias. All CPs that calculate these indices use the same weighting method 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.

TABLE 9 LONG INTERRUPTION – INDICES FOR QUANTIFYING

Country	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)
FYR of Macedonia	Distribution -SAIDI, SAIFI, CAIDI (Requested by Grid Code, but no data yet)	Not applicable (no rules, SCADA is used on HV level)
Kosovo*	Distribution-SAIDI, SAIFI, ENS (Transmission)	The number of customers (manually by DSO)
Montenegro	SAIDI and SAIFI for DSO, ENS and AIT for TSO	Not applicable
Serbia	Distribution – SAIDI, SAIFI, CAIDI; AITS, ENS (Transmission)	Distribution indicators (SAIDI, SAIFI) – number of customers; transmission indicators (AIT) – average power supplied (weighting is done manually according to the NRA rules)
Ukraine	SAIDI, SAIFI, ENS (only for distribution; for Transmission – data not yet available)	The number of customers

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.

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 CPs, 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.

For the purpose of this benchmarking, it is crucial to exclude the influence of CP specific factors from indices, caused by non-harmonized 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 CPs by excluding the impact of the exceptional events from the reported CoS index values (exceptional events are mostly not excluded from the interruption statistics), 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 exclusively relates to the responsibility of the performance of system operators is not feasible**.

Due to the lack of availability of the required data and the problems of comparability, the benchmarking analysis is focused on the indices that have been provided by at least four CPs:

- representing the value aggregated on the national level;
- comprising interruptions at all voltage levels monitored;
- 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.

TABLE 10 THE INDICES PROVIDED

Continuity indicator	Interruptions considered	Scope	BA	RS	UA	Kosovo*
UNPLANNED, SAIDI	**w/o exc. events (All networks)**	**Whole country**	**X**		**X**	**X**
UNPLANNED, SAIFI	**w/o exc. events (All networks)**	**Whole country**	**X**		**X**	**X**
UNPLANNED, SAIDI	**All interruptions (All networks)**	**Whole country**	**X**	**X**	**X**	**X**
UNPLANNED, SAIFI	**All interruptions (All networks)**	**Whole country**	**X**	**X**	**X**	**X**
PLANNED, SAIDI	**All interruptions (All networks)**	**Whole country**	**X**	**X**	**X**	**X**
PLANNED, SAIFI	**All interruptions (All networks)**	**Whole country**	**X**	**X**	**X**	**X**
UNPLANNED, MAIFI	All interruptions (All networks)	Whole country	X		X	
AIT (Transmission)	w/o exc. events (Only interruptions on T network)	Whole country, transmission system		X		X
ENS (Transmission)	**w/o exc. events (Only interruptions on T network)**	**Whole country, transmission system**	**X**	**X**		**X**
UNPLANNED, MAIFI	w/o exc. events (All networks),	Whole country			X	
Unplanned AIT (Transmission)	w/o exc. events (Only interruptions on T network)	Whole country, transmission system		X		
Planned AIT (Transmission)	w/o exc. events (Only interruptions on T network)	Whole country, transmission system		X		
Unplanned ENS (Transmission)	w/o exc. events (Only interruptions on T network)	Whole country, transmission system	X	X		
Planned ENS (Transmission)	w/o exc. events (Only interruptions on T network)	Whole country, transmission system	X	X		
UNPLANNED, SAIDI	w/o exc. events (Only interruptions on EHV networks)	Whole country, EHV	X			
UNPLANNED, SAIDI	w/o exc. events (Only interruptions on HV networks)	Whole country, HV			X	X
UNPLANNED, SAIDI	**w/o exc. events (Only interruptions on MV networks)**	**Whole country, MV**	**X**		**X**	
UNPLANNED, SAIDI	w/o exc. events (Only interruptions on LV networks)	Whole country, LV	X		X	X
UNPLANNED, SAIFI	w/o exc. events (Only interruptions on HV networks)	Whole country, HV			X	X
UNPLANNED, SAIFI	**w/o exc. events (Only interruptions on MV networks)**	**Whole country, MV**	**X**		**X**	
UNPLANNED, SAIFI	w/o exc. events (Only interruptions on LV networks)	Whole country, LV	X		X	X
UNPLANNED, MAIFI	w/o exc. events (Only interruptions on HV networks)	Whole country, HV			X	
UNPLANNED, MAIFI	w/o exc. events (Only interruptions on MV networks)	Whole country, MV			X	

Legend: All networks: EHV, HV, MV and LV; w/o exc. **Events:** Interruptions not attributable to exceptional events

Only two CPs, namely Bosnia and Herzegovina and Ukraine provided indices classified by territorial density. The reported set of indices per CP is shown in the table below.

TABLE 11 THE INDICES BY TERRITORIAL DENSITY

Continuity indicator	Interruptions considered	Scope	BA	UA
UNPLANNED, SAIDI	w/o exc. events (All networks)	Only urban areas	X	X
UNPLANNED, SAIFI	w/o exc. events (All networks)	Only urban areas	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	
UNPLANNED, SAIFI	w/o exc. events (All networks)	Only suburban areas	X	
UNPLANNED, SAIDI	w/o exc. events (All networks)	Only rural areas	X	X
UNPLANNED, SAIFI	w/o exc. events (All networks)	Only rural areas	X	X
UNPLANNED, MAIFI	w/o exc. events (All networks)	Only rural areas		X

2.4.1. Interruptions originated on different voltage levels

Considering all facts and issues discussed above, strengthened by the fact that incidents on MV contribute to the continuity indices the most (at least 70%), the available aggregated data of all those comparable indices that comprises the interruptions that occurred 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 covers only 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.

TABLE 12 UNPLANNED SAIDI (ALL EVENTS; HV, MV, LV) – THE DISTRIBUTION OF INCIDENTS ACCORDING TO THEIR VOLTAGE LEVEL [%]

Country	2011	2012	2013	2014	Avg
Albania – LV	n/a	n/a	n/a	n/a	n/a
Albania – MV	n/a	96.33	84.60	77.57	86.17
Albania – HV	n/a	15.88	33.10	34.25	27.74
Bosnia and Herzegovina (E RS only) - LV					
Bosnia and Herzegovina (E RS only) - MV					
Bosnia and Herzegovina (E RS only) - HV					
FYR of Macedonia - LV					
FYR of Macedonia - MV					
Kosovo* - LV		92.5	89	93	91
Kosovo* - MV					
Montenegro - LV					
Montenegro - MV					
Serbia - LV					
Serbia - MV					
Ukraine - LV	86.3	75.6	86.2	91.9	85.0
Ukraine - MV	428.1	429.3	435.7	435.9	432.3
Ukraine - HV (1)	4.4	6.9	5.2	6.5	5.8

(1) Not attributable to exceptional events.

TABLE 13 UNPLANNED SAIFI (ALL EVENTS; HV, MV, LV) – THE DISTRIBUTION OF INCIDENTS ACCORDING TO THEIR VOLTAGE LEVEL [%]

Country	2011	2012	2013	2014	Avg
Albania – LV	n/a	n/a	n/a	n/a	n/a
Albania – MV	n/a	29.22	42.60	39.71	37.18
Albania – HV	n/a	7.19	10.50	12.15	9.94
Bosnia and Herzegovina (E RS only) - LV					
Bosnia and Herzegovina (E RS only) - MV					
Bosnia and Herzegovina (E RS only) - HV					
FYR of Macedonia - LV					
FYR of Macedonia - MV					
Kosovo*- LV		96	96	93	95
Kosovo*- MV					
Montenegro - LV					
Montenegro - MV					
Serbia - LV					
Serbia - MV					
Ukraine - LV	0.52	0.52	0.64	0.66	0.58
Ukraine - MV	3.41	3.68	3.83	3.94	3.72
Ukraine - HV (1)	0.12	0.14	0.11	0.12	0.12

(1) Not attributable to exceptional events.

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 – from the experience in the EU Member States, this portion is very small, especially if observed in the networks with relative small ratio of undergrounding on MV and LV.

2.4.2. The evaluation of the impact of exceptional events

A difference between the same type of indices comprising the exceptional events and those excluding exceptional events was identified in several CPs. This may be an indication of the presence of the exceptional events in the continuity indices – according to the CPs' 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 with exceptional events excluded (SAIDI and SAIFI due to incidents at MV only). The disaggregated data on continuity indices without exceptional events that include the interruptions recorded at HV, MV and sometimes also LV (Ukraine) voltage levels was aggregated and compared with the aggregated indices comprising the exceptional events: according to the definition, latter should comprise also the interruptions recorded at EHV.

The contribution of interruptions recorded on MV (supposedly without exceptional events) in the aggregated indices (covering interruptions in all networks and supposedly comprising exceptional events) 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 caused by the exceptional events in the indices.

TABLE 14 UNPLANNED SAIFI (ALL EVENTS; HV, MV, LV) – THE DISTRIBUTION OF INCIDENTS ACCORDING TO THEIR VOLTAGE LEVEL [%]

Country	2011	2012	2013	2014
Albania - MV				
Albania - Other (HV, EHV, exceptional events)				
Bosnia and Herzegovina - MV				
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				
FYR of Macedonia - MV				
FYR of Macedonia - Other (HV, EHV, exceptional events)				
Kosovo* - MV				
Kosovo* - Other (HV, EHV, exceptional events)		7.47	10.78	6.69
Montenegro - MV				
Montenegro - Other (HV, EHV, exceptional events)				
Serbia - MV			52.58	
Serbia - Other (HV, EHV, exceptional events)				
Ukraine - MV (1)	428.1	429.3	435.7	435.9
Ukraine - Other (LV, HV, EHV, exceptional events) (2)	221.4	305.6	267.2	1972.2

(1) Not attributable to exceptional events.
(2) Including exceptional events.

TABLE 15 UNPLANNED SAIFI (ALL EVENTS) – CONTRIBUTION OF MV TO THE AGGREGATED VALUE [%]

Country	2011	2012	2013	2014
Albania - MV				
Albania - Other (HV, EHV, exceptional events)				
Bosnia and Herzegovina - MV				
Bosnia and Herzegovina - Other (HV, EHV, exceptional events)				
FYR of Macedonia - MV				
FYR of Macedonia - Other (HV, EHV, exceptional events)				
Kosovo* - MV				
Kosovo*- Other (HV, EHV, exceptional events)		3.21	3.97	6.86
Montenegro - MV				
Montenegro - Other (HV, EHV, exceptional events)				
Serbia - MV			73.1	
Serbia - Other (HV, EHV, exceptional events)				
Ukraine - MV (1)	3.41	3.68	3.83	3.94
Ukraine - Other (LV, HV, EHV, exceptional events) (2)	1.45	1.64	1.73	9.62

(1) Not attributable to exceptional events.
(2) Including exceptional events.

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[9] 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 the EHV (the contribution of interruptions that could be attributed to the transmission exceeds the EU average). Possible reasons for this are:

- the “leakage” in recording of interruptions on MV (mostly manual processing): the portion of interruptions recorded on 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 methods used for calculation and the usage of estimation methods;
- differences between CPs as regards rules and interpretation of exceptional events.

9. i.e. inclusion/exclusion of interruptions recorded at EHV/LV level in different sets of indexes.

2.4.3. Network characteristics

An overview on available system data of particular CPs is given in Table 16. The networks vary a lot across CPs in their size and structure.

TABLE 16 INFORMATION ON NETWORK, EQUIPMENT, ENERGY SUPPLIED, NUMBER OF CUSTOMERS

SYSTEM DATA	measure unit	Albania	Bosnia and Herzegovina	FYR of Macedonia	Kosovo*	Montenegro	Serbia	Ukraine
Item # 1 - Length of networks		2014	2014	2014	2014	2014	2014	2014
Total length of circuits - EHV network	km				188		3498	22332
Total length of circuits - HV network	km			212	1043	1.300,40	5910	41200
Length of cable circuits - MV network	km			2.777	1166	1.420	13118	47108
Total length of circuits - MV network	km			8.662	6543	5.890	48557	349268
Length of cable circuits - LV network	km			3.697	423	1.686,42	15456	38313
Total length of circuits - LV network	km			15.452	11243	13.216	110018	415606
Item # 2 - Energy								
Transmitted/distributed energy (all customers)	TWh				5.2	3.267	28	133.9
Distributed energy (only MV and LV customers)	TWh			4.973	4.6	2.426	25	85.8
Item # 3 - Customers								
Number of MV connection points of final customers								92201
Number of LV connection points of final customers	number			699.948	491586	384.186	3579080	20776431
Item # 4 - Equipment								
Number of MV feeders starting from HV/MV or EHV/MV transf. stations	number			1.480	352			22825
Number of MV feeders equipped with remote control (SCADA)	number			642	149			13975 (1)
Item # 5 - General info								
Number of Distribution System Operators	number			2	1	1	5	44
Customers served by the largest Distribution System Operators	number			700.897	491823	384.732	935158	1836659
Customers served by the three largest Distribution System Operators	number			700.897	There is only one DSO	384.732-	2715105	4563995

(1) 2013 data.

Remark:
Total length as sum of length of underground cable circuits, bare overhead lines and insulated overhead lines (overhead cables). Distributed energy excluding self-consumption.

2.5. 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 NRAs by means of setting the targets on continuity at the system level:

- continuity standards set on system level;
- overall (continuity) standards;
- (average) required performance;
- (average) performance targets.

While some of the terms are not often used, some have a sound base in the CEER documents[10]. However, harmonization 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 the 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 on questionnaires provided by many CPs, it can be concluded that activities for assuring the maintenance and improvement of continuity levels, as well as activities to protect the worst served customers are ongoing or will be started soon.

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	Kosovo*	MD, ME (1), RS (2)		
Transmission	Kosovo*	RS	-	-
Definition of worst served customer	-			
Responsibility	AI, BA, ME, UA (NRA); MK, RS, Kosovo* (Shared)			
Publication of indices	AL (monthly), BA, Kosovo* (annually)			
Intention/plans for implementation	MK (2016-2018), ME (2012), RS (2013-2015), UA (ongoing)			

(1) 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.
(2) Defined by the Decree on Conditions for Electricity Delivery and the Grid Code.

No explicit regulatory or other definitions of the worse served customer are applied. Not all CPs publish data on indicators but, if, they are published mostly on annual basis. Only Albania reported monthly publication.

Montenegro protects special large industrial customers only by individual standards on continuity of supply.

Serbia also applies individual standards applied and set minimal requirements on duration of interruptions but no compensation scheme. Also in Kosovo*, the overall standards on continuity of supply were applied for 2011.

The economic effects and outcomes of the regulatory actions cannot be addressed, due to lack of data availability.

10. i.e. papers on smart grids, such as: Status Review on Regulatory Aspects of Smart Metering (Electricity and Gas) as of May 2009 (http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/Tab/E09-RMF-17-03_SmartMetering-SR_19-Oct-09.pdf), Final Guidelines of Good Practice on Regulatory Aspects of Smart Metering for Electricity and Gas (http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/Tab2/E10-RMF-29-05_GGP_SM_8-Feb-2011.pdf) etc.

2.6. EXPECTED DEVELOPMENTS ON CONTINUITY OF SUPPLY REGULATION

The regulation of continuity of supply will be for sure subject to further changes and developments in the future. Many CPs that have not implemented related rules yet will do so, while others will focus on improving their regulation. Making use of the experience and good regulatory practice within the EU will be of great help to CPs.

CPs are working towards a more comprehensive approach in regulation of continuity of supply, some of them analyzing the possibility to introduce the reward-penalty mechanism (a link between the continuity and tariffs).

All observed CPs have initially put emphasis to 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 harmonized and standardized 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 in a long journey towards better regulation.

2.7. 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 the phase that can start to back-up regulatory decisions** successfully. Different approaches to the regulation – driven by CPs' 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.

The comparative analysis of the monitoring schemes and the continuity of supply regulation across 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 classification of the interruptions by its cause is as well applied. In several CPs both number and duration of interruptions are available and almost harmonized combinations of indicators (SAIDI, SAIFI) are used. Short interruptions are barely recorded**. Few examples of regulatory practices with advanced regulation instruments applied, by means of continuity standards and incentive schemes, are identified in the region as well.

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;
- monitoring is performed in different level of detail;
- different sets of indicators are used, although basic indicators (i.e. SAIDI, SAIFI, ENS) are widely used;
- not all incidents are considered in the statistics (i.e. LV).

A lack of harmonization in the basic monitoring rules is also identified, but it is not predominant. The lack of emphasis on monitoring of continuity at the transmission level in some CPs may be result of an underestimation of its importance due to the robust network design enabling high reliability ("n-1" operational criteria), apparent low number of customers connected to the transmission network, the problem of weighting (atypical customers, specifics in calculation of certain continuity indexes) and the estimation (i.e. "ENS" based indices).

All CPs are encouraged to strengthen their efforts on further developing and optimizing their monitoring process and make further steps towards comprehensive and robust monitoring schemes. The transparency of data and its quality is essential. Findings and recommendations are provided as follows:

Finding 1
Rules, business processes and tools for automatic logging of interruptions are not applied in all countries

Many CPs reported only limited use of SCADA and prevailing manual recording of interruptions. Lack of rules for automatic recording of interruptions has a direct impact on completeness, robustness and the quality of data on interruptions collected. 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

Implementations of SCADA and its Distribution Management System (DMS) functions in a wider scope 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 harmonized. Deviations or CP specific rules should be adequately upheld.

Finding 2
Harmonization of interruption definitions is not achieved and the monitoring schemes are lacking comprehensiveness and efficiency

Some minor differences in definitions of interruptions exist. Available norms (EN 50160) and guidelines of good practice (5th CEER Benchmarking Report on Quality of Electricity Supply, 2011 are used. Not all types of interruptions are monitored. Transient interruptions are not monitored by any of the CPs and monitoring schemes are lacking efficiency: the main problem is in the way how the interruptions are recorded – in the absence of SCADA or Advance Metering Infrastructure (AMI) (i.e. for recording the interruptions on LV), manual logging of interruptions and data processing does not assure required efficiency and reliability of data.

RECOMMENDATION 2

MONITORING OF ALL BASIC INTERRUPTIONS TYPES SHOULD BE INTRODUCED, BASED ON HARMONIZED DEFINITIONS

It is recommended that all CPs harmonize 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 harmonization process.

Harmonization should aimed at meeting the following criteria:
- long interruptions > 3 min
- short interruptions > 1 s and ≤ 3 min
- transient interruptions ≤ 1 s

This way, the definitions of interruptions would be aligned with the definitions of interruptions provided by EN 50160 as well as with European practices (5th CEER Benchmarking Report on Quality of Electricity Supply, 2011).

Short interruptions do also have a negative impact on business and industrial customers, aside of household customers, and should therefore also get appropriate attention by the regulators.
It is recommended that some type of monitoring scheme for short interruptions is in place.

The fact that SCADA will be implemented in many CPs from scratch provides a good opportunity for the CPs to plan appropriate SCADA functions and the appropriate level of network coverage by SCADA, to ensure automatic recording of short interruptions. SCADA is usually implemented starting at the highest voltage levels and moving to the high-load-density parts of the lower-voltage levels. Short interruptions occur mainly 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 comprehensive monitoring scheme will be lower in comparison to the situations where existing SCADA lacking functionality is upgraded. 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.

NRAs should also decide on the extension of monitoring schemes with the transient interruptions.

Finding 3
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, the monitoring is not always performed on all voltage levels. Usually, data is collected on the HV and MV level only. LV has not been sufficiently covered yet – in the early stage, a similar status was observed in the EU. Consequently, whenever interruptions on the LV level are not monitored, the consumers connected to these levels (which are all domestic customers and the majority of non-domestic customers) will be affected more than suggested by the provided data.

The lack of monitoring or inefficient monitoring at LV 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 each incident in LV will affect much fewer customers than each incident on MV and higher voltage levels, incidents on LV cannot be neglected: the resulting interruptions often last longer[11] than interruptions due to incidents at higher voltage levels and are also important in number[12]. The SAIDI contribution from LV therefore might be even underestimated.

RECOMMENDATION 3

INTERRUPTIONS SHOULD BE ALSO MONITORED AT LV LEVEL

All CPs are encouraged to include monitoring of interruptions at all voltage levels including LV in the continuity of supply statistics. The cost-benefit analysis should be performed to evaluate different possibilities:

- automated recording based on AMI;
- development of methods for estimation of duration and number of affected customers (i.e. using functions of call centers);
- 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 organizational and technical measures.

Finding 4
Categories of interruption causes vary between CPs

Information on causes is essential for DSOs to improve continuity of supply. This is also true for the NRA 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 harmonization of the certain types of causes, but it may be useful to achieve harmonization of main categories.

Especially, the treatment of so called "third party" causes is sometimes mixed with the cause category of "exceptional events".

RECOMMENDATION 4

THE BASIC CAUSE CATEGORIZATION SHOULD BE HARMONIZED

The harmonization 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:

- the responsibility of system operator;
- third party; and
- exceptional events

Each interruption cause (not necessarily harmonized) shall be linked to the appropriate category. The usage of causes like "other", "not available", "unexplained" as main categories should be avoided as much as possible. Such causes may be used only as sub-types, being therefore linked to the particular cause category.

Among the interruption causes in the category "third party", the responsibility of another system operator (DSO or TSO) for an interruption shall be distinguished from the others by its own dedicated type of cause: the interruptions caused by another system operator need to be easily identifiable in the processes of determining the responsible party for the damages caused by interruptions.

The distinction between the main cause categories (to avoid mixing the "third party" and "exceptional events") shall be achieved by clear definitions.

11. LV networks are usually radial networks without redundancy.
12. According to the experience in some EU countries, the contribution of interruptions from LV to the continuity indicators (SAIFI and SAIDI) varies from 7% up to 30% on national level – this analysis is based on the evaluation of impacts of incidents on LV network that are mostly estimated based on notification through the phone calls (AMI is not installed).

Finding 5
Level of detail in calculating continuity indicators differs among CPs

Due to the fact that continuity is benchmarked 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 "in-depth" analyses.

The calculation on the level of individual system operators, region and area is not a common practice in CPs. Only two CPs calculate the indices in such detail. Also, only few CPs reported that they calculate indices per network type (according to the population density) – among them only3 CPs provided data on such indices. In each of these three CP the continuity of supply is much better in urban areas than in rural areas.

The lack of disaggregated CoS data hinders NRAs and system operators in their decisions (regulatory, R&D) on measures to be taken.

RECOMMENDATION 5

LOGGING OF INTERRUPTIONS SHALL COMPRISE ALL NECESSARY DETAILS TO ENABLE DISAGGREGATED CALCULATION OF CONTINUITY INDICES

Network operators should use the extended set of interruption properties[13] 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 NRA.

For NRAs, it is important to calculate the indices per system operator with a view to benchmark their performance and identify possible larger differences in the level of continuity of supply. The calculation of indices according to the network type (rural/suburban/urban networks) provides the 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 rules for classification that may not be harmonized, due to differences in the network structure and geography, as well as demographic characteristics of CPs. Non aggregated calculation of indices will ensure better flexibility for NRA when designing regulatory incentive schemes[14].

NRAs 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 such 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.

13. Control area, i.e. population density (urban/suburban/rural), voltage level, network type (cable/overhead), cause, sub-cause etc.
14. 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.

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 they are either not considered in the continuity statistics or are treated separately. From the available information, 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 event is of utmost importance when analyzing continuity of supply data. Although concepts of "exceptional events" are reported to be applied, the impact of exceptional events is not clearly 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 – the classification of incidents as an exceptional events may comprise also the interruptions due to the weather circumstances that occur once a year or more often (as lightning etc.).

RECOMMENDATION 6

PROPER USE AND TRANSPARENCY OF CONCEPTS OF "EXCEPTIONAL EVENTS" SHOULD BE ASSURED

The possibilities for harmonization of definitions on exceptional events should be explored. It is recommended that CPs harmonize the definition by means of the common characteristics of the natural and non-natural exceptional event. An exceptional event that is beyond the control of the system operator 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 since it is a foreseeable and predictable event in all CPs. The CP specifics aggravate the harmonization in further detail[15]. Harmonization of such detail is not feasible.

Until adequate harmonization has been achieved, it is recommended for each CP to transparently use the definitions and designations of their own regulation. The use of expressions, like "exceptional events", with an apparent intuitive meaning, but without a clear definition of the manner in which it is used can result in misinterpretation.

Network operators should appropriately and reasonably minimize effects of events that are outside of their control, in line with appropriate regulatory schemes.

15. For example, if snowstorms are not an exceptional event in the northern countries, it could be seen as an exceptional event in southern parts of the Energy Community.

Finding 7
The set of indicators in use does not provide a complete picture of continuity of supply

Most of the CPs calculate SAIDI and SAIFI 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 reported the use of (rough) estimation 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 observed from different aspects, using different indicators.

CPs are encouraged to gradually extend the set of continuity indicators used. 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 of the whole number of the affected network users (at the 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. in the transmission and distribution levels) should be avoided. The minimal set of indices used for measuring the level of continuity of supply in distribution and transmission should be harmonized.

Finding 8
Publication of continuity data is not performed in all CPs and differs

The publication of continuity data is not performed by all countries. Also, the frequency of reporting varies across countries. Publication of continuity data usually does not consider exceptional events.

RECOMMENDATION 8

PUBLICATION OF CONTINUITY DATA ON A REGULAR BASIS WITH EXPLANATORY NOTES

Publication of data is one of the primary regulatory instruments and should be applied as soon as data is available. Published comparison of company performance is very effective: it simulates a competitive environment and encourages companies to make improvements. Comparisons on supranational level are useful for NRAs 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 and at least once a year. System operators should provide explanatory notes on the data published. NRAs should likewise 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 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
Minimal continuity standards and incentive schemes are rare and have different formulations

The regulation framework in CPs is 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 9

GRADUAL IMPLEMENTATION OF INCENTIVE MECHANISMS IS ENCOURAGED

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 each CP develop its own reward/penalty regime taking into account its specific conditions[16]. The development of regulation should be gradual and the prerequisites for incentive schemes at any level should include 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.

16. Network development, investment levels, regional differences and automation projects.

3 VOLTAGE QUALITY

3.1. INTRODUCTION

This chapter provides an overview of the existing practice in voltage quality monitoring and regulation on transmission and distribution level in 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 analyzed:

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.

Information provided by the CPs on these categories is provided in Table 18.

TABLE 18 INDICATION OF PROVIDED VOLTAGE QUALITY INFORMATION BY DIFFERENT CPS

EnC Contracting Party	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	
FYR of Macedonia	Yes	Yes	Yes	Yes		
Kosovo*	Yes			Yes		
Montenegro	Yes			Yes		
Serbia	Yes			Yes		
Ukraine	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 STANDARDIZATION

Data regarding voltage quality implementation via legislation, regulation and standardization are provided by all the CPs. This implies that CPs have recognized the need for introducing voltage quality requirements into 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 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 CPs where it is implemented, EN 50160 is predominantly used as a standard for supply voltage variations. The implementation status of EN 50160 in each of the reporting CPs is presented in Table 19

TABLE 19 EN 50160 IMPLEMENTATION STATUS

EnC Contracting Party	Implementation status	Different standards from EN 510160 and the way they are enforced
Albania	Voluntary standard	Yes, national law
Bosnia and Herzegovina	partially, General conditions of supply and Grid Code; BA: fully from 2016 Republika Srpska: fully from 2015	Yes, national law, grid/distribution code
FYR of Macedonia	Yes partially MKC EN 50160:2009, Grid Code;	Yes, national law, grid/distribution codes
Kosovo*	Yes	Yes, distribution code
Montenegro	No	Yes, grid/distribution codes
Serbia	Voluntary standard.	Yes, national law, grid/distribution code
Ukraine	implemented as a voluntary standard	Yes, standards committee

3.2.2. Legislation 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 Ukraine, voltage quality limits for different voltage characteristics are defined by an interstate standard on voltage quality, GOST 13109-97, approved by the *Interstate Council of standardization, 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 are mainly ±5% for 400 kV, ±10% or ±5% for 220 kV and ±10% for 110 kV. Currently applied voltage quality standards in observed CPs are shown in Table 20.

TABLE 20 VQ STANDARDS ENFORCED/USED AT NATIONAL LEVEL

EnC Contracting Party	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% (BA)	Yes, IEC 61000-3-6, IEC 61000-3-7 IEC 61000-3-12, national standards
FYR of Macedonia	EHV: ±5%; HV, MV: ±10% LV: +5%, -10%	No, MKC EN 50160:2009
Kosovo*	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, distribution code
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%	
Ukraine	All voltage levels: ±5% (95% of the time) ±10% (marginal voltage variation) or EN 50160:2010 (with some amends: LV voltage 220 kV) (must be determined in contract)	Yes, GOST 13109-97 and EN 50160:2010

3.2.3. Obligations for monitoring voltage quality

Monitoring voltage quality requires monitoring of voltage quality parameters with voltage quality monitoring instruments in such a way that provides a system-wide evaluation. In some CPs, a direct obligation for the TSO/DSOs to measure voltage quality parameters on a continuous basis or at predefined intervals has been introduced by legislation and regulation.

However, **in the majority of the 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 Macedonia legislation defines detailed procedure and obligations for the implementation of a voltage quality monitoring system: in line with the provisions for implementation of a voltage quality monitoring system, the legal framework in FYR of Macedonia also prescribes provisions for collection, aggregation and publication of voltage quality data from the voltage quality monitoring system.

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[17] require that measurements of voltage quality have to be 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 NRA was operational.

In the majority of the 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 own connection point. For the rest of the reporting CPs, the common practice is that 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 that the voltage quality proofs to comply with the requirements. A possibility for an end-user to install its own voltage quality recorder and use measurement in a dispute with the TSO/DSOs is not recognized in the majority of the CPs, except in Ukraine where such a procedure is defined. Monetary penalties in cases where quality limits are not met are foreseen only in Ukraine.

3.2.4. 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.

17. Of FERC.

TABLE 21 VQ MEASUREMENT OBLIGATIONS

EnC Contracting Party	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
FYR of Macedonia	Yes	Yes	Yes, operator pays if request justified	No	No
Kosovo*	No	No	Yes	No	Upon user's request
Montenegro	Yes	Yes	Yes, no pre-defined payment by user	No	No
Serbia	No	No	No	No	No
Ukraine	Yes	No	Yes	Yes	No

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 NRA. However the responsibilities are not clearly legally defined. The role of the NRA is mainly limited to approving codes, while the direct authority for voltage quality regulation is not defined.

3.2.5. 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 the 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 by the grid and distribution codes[18]. However, **different approaches are identified in defining emission limits**. In the majority of the CPs, such as Bosnia and Herzegovina, Montenegro and Kosovo*, 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 maximum levels of electricity current emissions are set for the installations connected to the 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. Other CPs still have not installed any 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 done on the HV/MV delivery points between the TSO and the DSO with portable instruments, namely with 1 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. In some CPs a small number of smart meters has been already installed but those meters do not allow voltage quality monitoring and there are no such functionality requirements for smart meters imposed.

18. Namely in the chapters dealing with connection to the transmission and distribution network.

3.3.3. Data collection, aggregation and publication from VQMS

Taking into account that most of the surveyed CPs still do not have a 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 in the central computer and available upon request of the NRA and network users. These data have been published only in the 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. Additionally, there are no reported data on mitigation measures from any of the CPs concerned.

Only Bosnia and Herzegovina has provided some monitoring data of VQ parameters. Bosnia and Herzegovina has reported 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 parts of 2008 (91 day). Data for the following years were not available. In the period 27March 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, a study has been made 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 the majority of the 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 as a reference to the EN 50160 or by taking over the limits given in the legislation and regulation. EN 50160 is mainly applied on low and medium voltage levels up to 35 kV. Additionally, it is predominantly used as a standard for supply voltage variations. In most of the CPs EN 50160 has not been translated into local language.

Voltage quality standards that differ from EN 50160, such as IEC 61000-x-x have been introduced for some voltage characteristics, mainly via 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 have adopted, but have not translated EN 50160 should make the effort to translate EN 50160 in order 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 this already should further improve the precision of definitions, limitations and exceptions. Since most CPs have been 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 should be avoided as much as possible keeping in mind national specifics.

The previous recommendations are preconditions for NRAs 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 legal and regulatory frameworks of the majority of the CPs. FYR Macedonia is the only CP where legislation defines detailed procedure and obligations for implementation of a voltage quality monitoring system.

RECOMMENDATION 2

INTRODUCTION OF VOLTAGE QUALITY MONITORING OBLIGATIONS

Direct obligations, as well as detailed procedures for establishment of a voltage quality monitoring system, should be defined in the 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 as well.

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 and therefore they were not able to provide relevant data on actual voltage quality levels. 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 encourage T/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 data from continuous voltage quality monitoring can provide useful information for T/DSOs, resulting in significant cost savings and information to support investment decisions.

Having in mind that implementation of voltage quality monitoring systems has not started yet in CPs, it is recommended for the CPs – prior to the implementation – to undertake joint activities towards harmonization of voltage quality parameters and measurement methods.

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 about the need for compulsory or regulator-controlled monitoring.

Finding 4
Individual voltage quality verification is available in the majority of the CPs

In majority of the CPs T/DSOs are legally obliged to provide individual voltage quality verification upon request of end-users who experience voltage quality problems. In several CPs, even without a legal obligation, in practice T/DSOs perform individual voltage quality verification. In most of the cases, costs are paid by the T/DSO, while in some CPs costs are paid by the customer in the case that voltage quality proofs to comply with the requirements. An obligation of providing individual information on voltage quality is still not legally defined in the majority of the CPs.

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[19]. 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 in 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 4

INTRODUCTION AND DEVELOPMENT OF INDIVIDUAL VOLTAGE QUALITY VERIFICATION PROVISIONS

The legal obligation for T/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 T/DSOs ensuring that all relevant information about the procedure is available to customers, including 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 or at least for identifying areas that should be investigated further. NRAs should use such statistics for regulatory decisions regarding voltage quality.

It is further recommended that statistics on complaints and verification results are correlated with 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.

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 T/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.

19. Namely in the chapters dealing with connection to the transmission and distribution network.

4 COMMERCIAL QUALITY

4.1. INTRODUCTION

The answers received indicate that regulation of Commercial Quality (CQ) is still in an early stage in all assessed CPs.

The questionnaire used for the present survey stressed the complexity of CQ with multiple suppliers and regulated entities like DSO and Universal Service Providers (USP). A brief examination of a supposedly simple business process, like solving a Voltage Quality complaint, reveals that CQ standards are strongly correlated with the market design and legal framework. **For most CPs this implies the need to further develop legislation and practice to accommodate even basic service quality regulation.** For example, concerning 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, CQ requirements have been categorized in two main and two supplementary types:

- **Guaranteed Standards** (GSs) refer to 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 guaranteed standards 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. Overall standards 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** (OAR). 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 defined by the regulator, e.g. a minimum level which must be met 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 cases.

- **Only Monitoring** (OMs). Before issuing GSs and OSs, regulators (and/or other competent parties) can monitor the performance of DSOs, suppliers, universal suppliers and/or 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.

Commercial quality has been reviewed by using the following four groups of indicators:
- Connection (Group I);
- Customer Care (Group II);
- Technical Service (Group III);
- Metering and Billing (Group IV).

The assessment shows an overwhelming use of explicit provisions regarding quality where standard is applied to all (100%) cases (Table 22). Although such provisions are in essence GSs, in line with the benchmarking guidelines, such standards are labeled as OARs because there is no compensation for individual customers and often there is no penalty defined for the company. For most of these standards, penalties are based either on vague and imprecise general penal provisions or simply do not exist (even if required by primary legislation). Additionally, it should be mentioned that the OARs present in the CPs are usually not influenced by the NRA, but are rather defined by primary or secondary legislation.

Table 22 shows that commercial quality in CPs is enforced largely by OAR (91 within the total of 116).

TABLE 22 COMMERCIAL QUALITY

Country	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
FYR of Macedonia	0	0	13	0	13
Kosovo*	0	8	11	0	19
Montenegro	0	0	10	0	10
Serbia	0	0	15	6	21
Ukraine	0	0	13	0	13
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 client 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**

Table 23 shows that there is no particular group with a prevalent 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 (Table 23), it is visible that indicator "I.3 Time for connecting new customers to the network" has the highest number of standards. Closely behind 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 is presently not informative since national electricity markets are developing. Therefore, an overview of standards and data availability with respect to relevant company is skipped. However, some remarks will be given in chapters analyzing particular groups of indicators.

It should be noted that the current benchmarking is more focused on commercial performances of the 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.

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 questionnaire used for the present survey 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 instead rather differentiate connection procedures based on the type of customer. In addition to the obvious household type, categorizations 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	Countries (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:** AL **OAR:** BA, MK, ME, RS, UA, Kosovo*	25 days (15 - 30 days)	-	DSO
Time for cost estimation for simple works	**OS:** AL **OAR:** BA, MK, Kosovo* **None:** ME,RS, UA	21 days (8 - 30 days)	-	DSO
Time for connecting new customers to the network	**OS:** AL, Kosovo* **OAR:** BA, MK, ME, RS, UA **None:**	20 days (4- 45 days)	-	DSO
Time for disconnection upon customer's request	**OAR:** MK, ME, RS, UA, Kosovo* **O/M:** BA **None:** AL	12 days (3- 30 days)	-	DSO

4.3.2. Group II – Customer Care

Customer Care relates to the group of indicators with the least number of standards. For certain indicators none of the CPs has adopted standards. Of course it can be argued that this is a direct reflection of the low level of competition. Another reason that can be valid is that liberalization of energy sectors is lagging behind comparing to EU countries.

Direct interaction with customers is not monitored – starting with the lack of call centers (used by DSOs and incumbent suppliers), appointments and visits are not planned/recorded, etc.

Another aspect is that DSOs and incumbent companies have not been focusing 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. That is the reason why CPs cannot obtain data regarding indicators related to customer care as defined in the questionnaire used for the present survey.

TABLE 25 COMMERCIAL QUALITY STANDARDS FOR CUSTOMER CARE ACTIVITIES

Quality Indicator	Countries (grouped by type of standard)	Standards (median value and range)	Compensation (median value, GS only)	Company involved
Punctuality of appointments with customers	OAR: BA None: AL, MK, ME, RS, UA, Kosovo*	-	-	DSO
Response time to customer complaints and enquiries (total, including 6a and 6b)	OAR: BA, MK, ME, UA, Kosovo* O/M: RS None: AL	26 days (15 - 30 days)	-	DSO
Time for answering the voltage complaint (as part of q6)	OAR: BA, MK, ME, UA, Kosovo* O/M: RS None: AL,	16 days (2- 30 days)	-	DSO
Time for answering the interruption complaint (as part of q6)	O/M: RS OAR: MK, ME, Kosovo* None: AL, BA, UA	20 days (15- 30 days)	-	DSO
Response time to questions in relation with costs and payments (excluding connection)	OAR: BA, ME, UA, Kosovo* None: AL, MK, RS	8 days (1h- 8 days)	-	DSO
Call Centres average holding time	-	-	-	-
Waiting time in case of personal visit at client centres	-	-	-	-

Table 25 clearly shows that all CPs lack standards related to Call Centers and do not record visits/appointments. This information has been intentionally left in the table to emphasize the need to develop 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. The reason is that different CPs 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 in charge. 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.

TABLE 26 COMMERCIAL QUALITY STANDARDS FOR TECHNICAL SERVICES

Quality Indicator	Countries (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	OS: Kosovo* OAR: BA, RS, UA None: AL, MK, ME	25 days (1 - 60 days)	-	DSO
Time until the start of restoration of supply following failure of fuse of DSO	OS: Kosovo* OAR: MK O/M: BA None: AL, ME, RS, UA	12 hours (1 - 24 hours)	-	DSO
Time for giving information in advance of a planned interruption	OS: Kosovo*, MD OAR: BA, MK, RS, UA None: AL, ME	3 days (1 - 10 days)	-	DSO
Time until the restoration of supply in case of unplanned interruption	O/M: BA OAR: MK, RS, UA None: AL, ME, Kosovo*	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 27) 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 viewed as "time from sending the notice…" or "Time from the notice is received…"

Similar to the group "Technical Services", standards within "Billing and Metering" depend 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 27 COMMERCIAL QUALITY STANDARDS FOR BILLING AND METERING

Quality Indicator	Countries (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: BA, MK, RS, UA, Kosovo* None: AL, MK	14 days (2 - 30 days)	-	DSO, MO
Time from the notice to pay until disconnection	OAR: BA, MK, ME, RS, UA, Kosovo* None: AL	13 days (3 - 30 days)	-	DSO
Time for restoration of power supply following disconnection due to non-payment	OAR: BA, MK, ME, RS, UA, Kosovo* None: AL,	2 days (1 - 7 days)	-	DSO, SP
Time until the restoration of supply in case of unplanned interruption	OAR: BA, MK, ME, RS, UA, Kosovo* None: AL	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 development stage in all surveyed CPs. Therefore, all general recommendations for developing quality of service standards can apply. However, there four issues specific for the CPs that should be recognized. It should be also 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 an tremendous number of complaints that must be handled (by the utility or the NRA).

Therefore, starting from the existing standards, new ones should be created based on the following approach:
- Exemptions should be possible, allowing same 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);
- 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 5th CEER Benchmarking Report on Quality of Electricity Supply showed that countries in the Central East of Europe (CEE) use predominantly guaranteed standards. Due to similarities between CEE countries and the 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, universal service provides and others. Currently, the distinction between standards applied to DSOs, suppliers, universal service provides is not informative for the CPs since electricity markets are at early development stage.

RECOMMENDATION 2

CQ STANDARDS SHOULD BE CREATED HAVING IN MIND DIFFERENT ENTITIES (DSOs, SPs, USPs, ETC.) AND DIFFERENT MARKET MODELS

The existence of different entities (DSOs, SPs, 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, "Time until the restoration of supply in case of unplanned interruption" is not universally applicable and may distort benchmarking results.

This also implies that NRAs should have deep insight in the procedures of suppliers.

It may be argued that CQ standards should be tied to regulated activities (DSO/USP/ regulated SP).

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 NRA a more serious issue afflicting the supplier.

It should be emphasized that the 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, NRAs 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 MS 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 been focused on customers but predominantly on their own activities. Most of their statistical data which can be correlated with commercial standards is related to the "system". Historically, they had 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 Customer Relationship Management (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 to track 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 – TABLE OF TABLES

LIST OF ABBREVIATIONS

Term	Definition
ACER	Agency for the Cooperation of Energy Regulators
ACM	The Netherlands Authority for Consumers and Markets (Dutch National Regulatory Authority)
AIT	Average Interruption Time
AMI	Advanced Metering Infrastructure
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
CEER	Council of European Energy Regulators
CEMI	Customer Experiencing Multiple Interruptions
CENELEC	European Committee for Electrotechnical Standardization
CI	Customer Interruptions
CIGRE	International Council on Large Electric Systems
CIRED	International Conference on Electricity Distribution
CML	Customer Minutes Lost
CoRDiS	The Standing Committee for Disputes and Sanctions (France)
CoS	Continuity of Supply
CQ	Commercial Quality
CRE	Commission de Régulation de l'Energie (French National Regulatory Authority)
CTAIDI	Customer Total Average Interruption Duration Index
DNO	Distribution Network Operator
DSO	Distribution System Operator
DVGW	German Technical and Scientific Association for Gas and Water
ECRB	Energy Community Regulatory Board
EHV	Extra High Voltage
EI	Swedish Energy Markets Inspectorate (Swedish National Regulatory Authority)
EMC	Electromagnetic Compatibility
END	Energy Not Distributed
ENS	Energy Not Supplied
ERDF	Electricity Distribution Network France
ERSE	Entidade Reguladora dos Serviços Energéticos / Energy Services Regulatory Authority (Portuguese National Regulatory Authority)
EU	European Union
GGP	Guidelines of Good Practice
GI	Guaranteed Indicators
GIS	Geographic Information System

Term	Definition
GRDF	Gaz Réseau Distribution France
HEO	Hungarian Energy Office (Hungarian National Regulatory Authority)
HP	High Pressure
HV	High Voltage
IEC	International Electrotechnical Commission
IEEE	(formerly) Institute of Electrical and Electronics Engineers
LNG	Liquefied Natural Gas
LP	Low Pressure
LV	Low Voltage
MAIFI	Momentary Average Interruption Frequency Index
MAIFIE	Momentary Average Interruption Event Frequency Index
MO	Meter Operator
MP	Medium Pressure
MV	Medium Voltage
NA	Not Applicable
NIEPI	Equivalent number of interruptions related to the installed capacity
NRA	National Regulatory Authority
NVE	Norges Vassdrags – og Energidirektorat (Norway)
Ofgem	Office of Gas and Electricity Markets (British National Regulatory Authority)
OI	Overall Indicators
OR	Other Requirements
r.m.s.	Root Mean Square
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SEWRC	State Energy and Water Regulatory Commission (Bulgaria)
SP	Supplier
THD	Total Harmonic Distortion
TIEPI	Equivalent interruption time related to the installed capacity
TNC	Transmission Network Code
T-SAIFI	Transformer System Average Interruption Frequency Index
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
WI	Wobbe Index

LIST OF COUNTRY ABBREVIATIONS

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
GB	Great Britain (GB is used for Great Britain: England, Scotland and Wales)
EL	Greece
HU	Hungary
IS	Iceland
IE	Ireland
IT	Italy
KS	Kosovo
LV	Latvia
LT	Lithuania
LU	Luxembourg
MK	The Former Yugoslav Republic of Macedonia (FYR of Macedonia)
MT	Malta
MD	Moldova
ME	Montenegro
NL	The Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
SK	Slovak Republic
SI	Slovenia
ES	Spain
SE	Sweden
CH	Switzerland
UA	Ukraine

LIST OF REFERENCES

[1] CEER, "Quality of Electricity Supply: Initial Benchmarking on Actual Levels, Standards and Regulatory Strategies," 2001.

[2] CEER, "Second Benchmarking Report on Quality of Electricity Supply," 2003.

[3] CEER, "Third Benchmarking Report on Quality of Electricity Supply 2005," 2005.

[4] CEER, "4th Benchmarking Report on Quality of Electricity Supply 2008," 2008.

[5] CEER, "5th CEER Benchmarking Report on the quality og Electricity Supply 2011," 2012.

[6] SINTEF Energy Research, ""Study on estimation of costs due to electricity interruptions and voltage disturbances"," TR F6978, December 2010..

[7] "Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances," 7 December 2010, Ref: C10-EQS-41-03, http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2010/C10-EQS-41-03_GGP%20interuptions%20and%20voltage_7-Dec-2010.pdf.

[8] CENELEC, "Interruption indexes," Technical Report TR 50555, 2010..

[9] N. Pereira, S. Faias and J. Esteves, "Impact of Techno-economic Context on the Continuity of Supply of the European Distribution Networks," Lisbon Engineering Superior Institute (ISEL), Entidade Reguladora dos Serviços Energéticos (ERSE), INESC ID, 2016.

[10] Galvin electricity initiative, "Electricity Reliability: problems, progress and policy solutions," http://www.galvinpower.org/sites/default/files/Electricity_Reliability_031611.pdf, 2011.

[11] A. A. Chowdhury and D. O. Koval, "Power Distribution System Reliability: Practical Methods and Applications," IEEE Press, John Wiley & Sons, Inc., 2009.

[12] E. Fugmagalli, L. Lo Schiava and F. Delestra, "Service quality regulation in electricity distribution and retail," Springer, 2007.

[13] CEER, "Guideline of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances," 2010.

[14] CEER, ECRB, "Guidelines of Godd Practice on the Implementation and Use of Voltage Quality Monitoring Systems for Regulatory Purposes," 2012.

[15] EN 61000-4-30, "Power Quality Monitoring EURELECTRIC Views," 2009.

[16] Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC ("EMC Directive").

[17] EURELECTRIC , "Power Quality Monitoring EURELECTRIC Views," 2009.

[18] CEER, "Status Review of Retulatory Aspects of Smart Meetering, including an assesment of roll out as of 1 January 2013," 12. september 2013.

[19] S. K. S. Taxt, "Storskale spenningsmåling md AMS," Sintef Energi, 2014.

[20] IEC, IEC/PAS 62559, "IntelliGrid Methodology for Developing Requirements for Energy Systems.," 2008.

[21] REN – Rede Eléctrica Nacional, S.A., "Qualidade de Energia Elétrica [Online]. Available: http://www.ren.pt/pt-PT/o_que_fazemos/eletricidade/qualidade_de_energia_electrica/," 2014.

[22] P. S. a. G. W. J. Meyer, "Efficient method for power quality surveying in distribution networks," in *CIRED conference*, Turin , 6-9 June 2005.

[23] K. Consulting, "Premium Power Quality contracts and labelling," Arnhem, Apr. 2007.

[24] S. EDP Distribuição – Energia, "Qualidade de Energia Elétrica [Online]. Available: http://edp-distribuicao.waynext.com/," 2014.

[25] C. –. C. E. d. V. D'Este, "Qualidade da Onda de Tensão 2014 [Online]. Available: http://www.ceve.pt/index.php?cat=108&item=2125," 2014.

[26] S. Faias and J. Esteves, "Guidelines for Publication of Voltage Quality Monitoring Results in Portugal: A Regulatory Perspective," *International Conference on Renewable Energies and Power Quality* (ICREPQ'16).

[27] "Network code on interoperability and data exchange rules," http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R0703.

[28] "General Information Wobbe Index and Calorimeters, Hobre," http://www.hobre.com/files/products/Wobbe_Index_general_information.pdf.

[29] "Calculation of Hydrocarbon Dew Point, Effectech," http://www.effectech.co.uk/downloads/applicationnotes.php.

[30] "Standard CEN EN 16726: Gas infrastructure – Quality of gas – Group H," https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:38695, 6215&cs=1E95E0B2AB2FE827AC0028AFF21E62B81.

[31] CENELEC EN 50160, "Voltage Characteristics of electricity supplied by public electricity networks," 2010.

[32] CIGRE Technical Brochure TB 412, "Voltage dip immunity of equipment and installations", April 2010.

[33] EN 61000: Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods.

[34] "Directive 2009/72/EC of the European Parlament and of the Council of 13 July 2009 concerning common rules of the internal market in electricity and repealing Directive 2003/54/EC ("Third Package")".

[35] L. P. a. A. Tavares, "Power quality of supply characterization in the Portuguese electricity transmission grid," in *CIRED conference*, Stockholm , 10-13 June 2013.

[36] CENELEC, "EN 50160, Voltage characteristics of electricity supplied by public electricity networks," 2010.

ABOUT 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. CEER's members and observers (from 33 European countries) are the statutory bodies responsible for energy regulation at national level.

One of CEER's key objectives is to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market that works in the public interest. CEER actively promotes an investment-friendly and harmonised regulatory environment, and consistent application of existing EU legislation. Moreover, CEER champions consumer issues in our belief that a competitive and secure EU single energy market is not a goal in itself, but should deliver benefits for energy consumers.

CEER, based in Brussels, deals with a broad range of energy issues including retail markets and consumers; distribution networks; smart grids; flexibility; sustainability; and international cooperation. European energy regulators are committed to a holistic approach to energy regulation in Europe. Through CEER, NRAs cooperate and develop common position papers, advice and forward-thinking recommendations to improve the electricity and gas markets for the benefit of consumers and businesses.

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 Task Force of CEER'S Distribution Systems Working Group.

CEER wishes to thank in particular the following regulatory experts for their work in preparing this report: A. Ånestad, A. Candela, H. Fadum, S. Faias, S. Hilpert, P. Kusy, J. Liska, H. Pousinho, O. Radovic, E. Tene, J. Vincent, J. Vogado and M. Westermann.

More information at **www.ceer.eu.**

Design by:
www.generis.be

Photos credits:
iStockphoto (p.6-7, p.8-9); shutterstock (cover, p.16, p.18, p.80, p.110, p.138, p.164, p.176)

CEER

Council of European Energy Regulators

Council of European Energy Regulators (CEER)
Cours Saint-Michel 30a, box F
1040 Brussels
Belgium
Tel: + 32 2 788 73 30
Fax: + 32 2 788 73 50

www.ceer.eu
brussels@ceer.eu
twitter.com/CEERenergy