CEER – ECRB – EURELECTRIC Joint Workshop on "Voltage Quality Monitoring"

Experience with VQM in Portugal

edp distribuição

Brussels - 1 October 2012

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Drivers and methodology of PQ management

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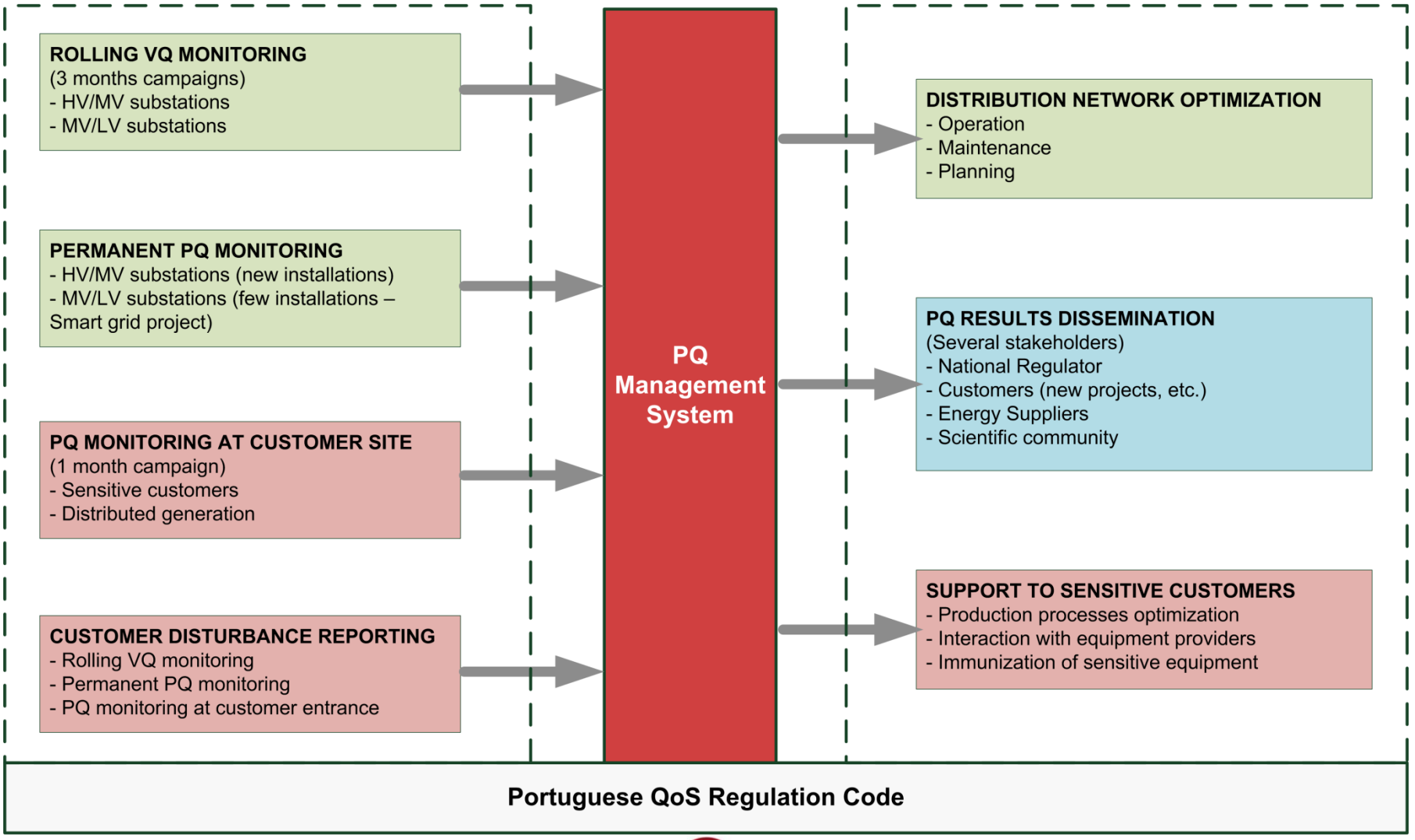

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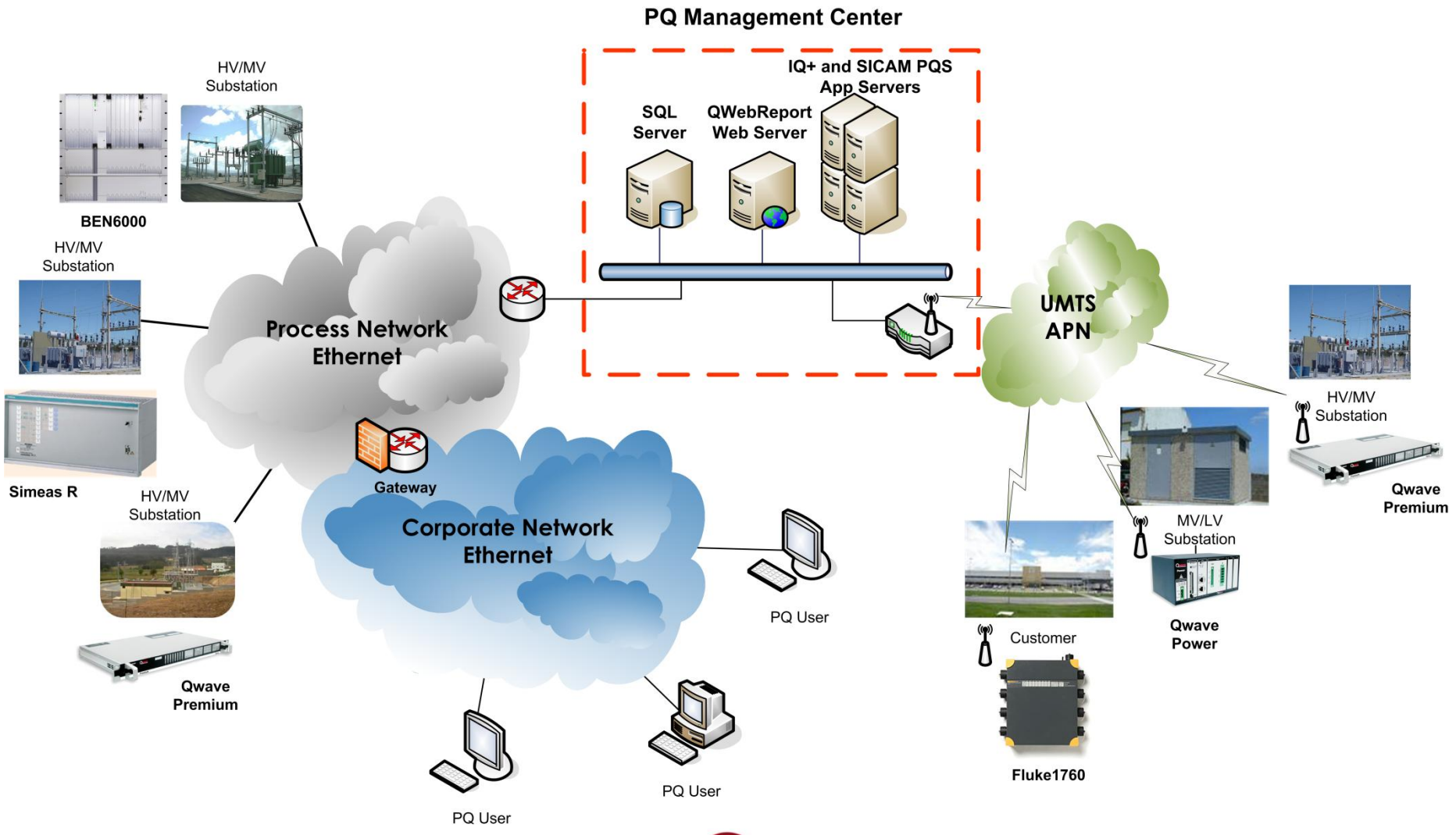
PQ monitoring platform

Overview

Eligible Monitoring Sites (EDP area)	Regulation Requirements (PT)	Approach EDP	Available Resources EDP	Regular Dissemination
HV/MV Substations 370 (517 MV Busbars) 	Monitor all MV busbars every 4 years Monitoring period: At least 1 week	**Rolling monitoring** (3 months campaigns)	30 VQM devices (60 MV busbars capacity)	**National Regulator** Quarterly VQ Report Annual QoS Report **EDP** PQ Report - Support improving actions in network **MV Customers** PQ Report - Feedback and support improving actions
		Permanent monitoring (New HV/MV substations)	29 PQM devices (42 MV busbars) (IEC 61000-4-30 Class A)	
MV/LV Substations 64 458 LV Busbars 	Monitor at least 2 substations/municipality (2x278=556) every 4 years Monitoring period: At least 1 week	**Rolling monitoring** (3 months campaigns)	44 PQM devices	
		Permanent monitoring (Few units of smart grid project)	22 VQM devices (Distribution transformer controllers)	
HV and MV Customers 23 773 	Customer entrance monitoring upon request Customer entrance monitoring if required Monitoring period: To be defined by EDP	**Upon request** (At Customer entrance)	10 PQM devices (IEC 61000-4-30 Class A) Customer reporting	**EDP** PQ Report - Support improving actions in network **Customers** PQ Report - Feedback and support improving actions
		By invitation (Rolling/permanent monitoring)	Customer reporting	
LV Customers 6 060 274		**Upon request** (At Customer entrance)	50 VQM devices	

PQ monitoring platform

Communications network topology

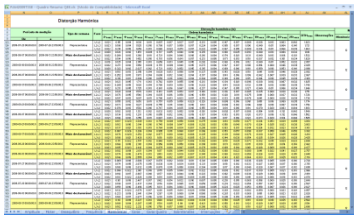


PQ monitoring platform

Reporting architecture

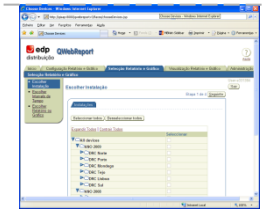
VQ Reporting (Requirements of QoS Regulation Code)

VQ Report to the National Regulator



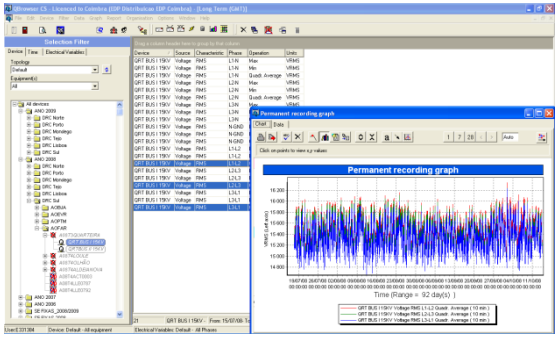
VQ data processing and reporting

VQ Reporting tool



PQ data storage and management

Central Data Base



PQ Monitoring HV/MV and MV/LV substations

PQM device

PQM device

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VQ analysis and reporting

Quarterly report to the National Regulator

Continuous phenomena

Continuous phenomenon	Monitoring period	No. monitoring weeks	No. weeks non-compliant	Selection of weeks Representative/Worst	Phases to provide data	Min value	P0.5%	P01%	P05%	P95%	P99%	P99.5%	Max value
RMS voltage variations	start/end dates	No.	No.	Representative week	ph1, ph2, ph3	Umin (V)		U (V)	U (V)	U (V)	U (V)		Umax (V)
				Worst week	ph1, ph2, ph3	Umin (V)		U (V)	U (V)	U (V)	U (V)		Umax (V)
Frequency	start/end dates	No.	No.	Representative week	ph1	fmin (Hz)	f (Hz)					f (Hz)	fmax (Hz)
				Worst week	ph1	fmin (Hz)	f (Hz)					f (Hz)	fmax (Hz)
Flicker (Pst and Plt)	start/end dates	No.	No.	Representative week	ph1, ph2, ph3					pu			
				Worst week	ph1, ph2, ph3					pu			
Unbalance	start/end dates	No.	No.	Representative week	ph123					%			
				Worst week	ph123					%			
Harmonics (2nd - 25th)	start/end dates	No.	No.	Representative week	ph1, ph2, ph3					%			
				Worst week	ph1, ph2, ph3					%			
THD	start/end dates	No.	No.	Representative week	ph1, ph2, ph3					%			
				Worst week	ph1, ph2, ph3					%			

Representative and worst weeks selected by a VQ index

- VQ index computed for every monitoring week
- VQ index based on normalized deviations of all continuous phenomena, per phase, face to respective EN50160 threshold
- Worst Week – The largest VQ index
- Representative Week – Median of VQ indices (odd no. of weeks) or Under median closest VQ index (even no. of weeks)

VQ events

VQ events	Monitoring period	Amplitude/duration table	No. of events	Max. extreme value	Duration [Max. extreme value]	Max. duration	Extreme value [Max. duration]	Cumulative duration
Voltage dips	start/end dates	Yes	No.	Umin (V)	t (ms)	t (ms)	Umin (V)	
Voltage swells	start/end dates	Yes	No.	Umax (V)	t (ms)	t (ms)	Umax (V)	
Interruptions	start/end dates		No.			t (min)		t (min)

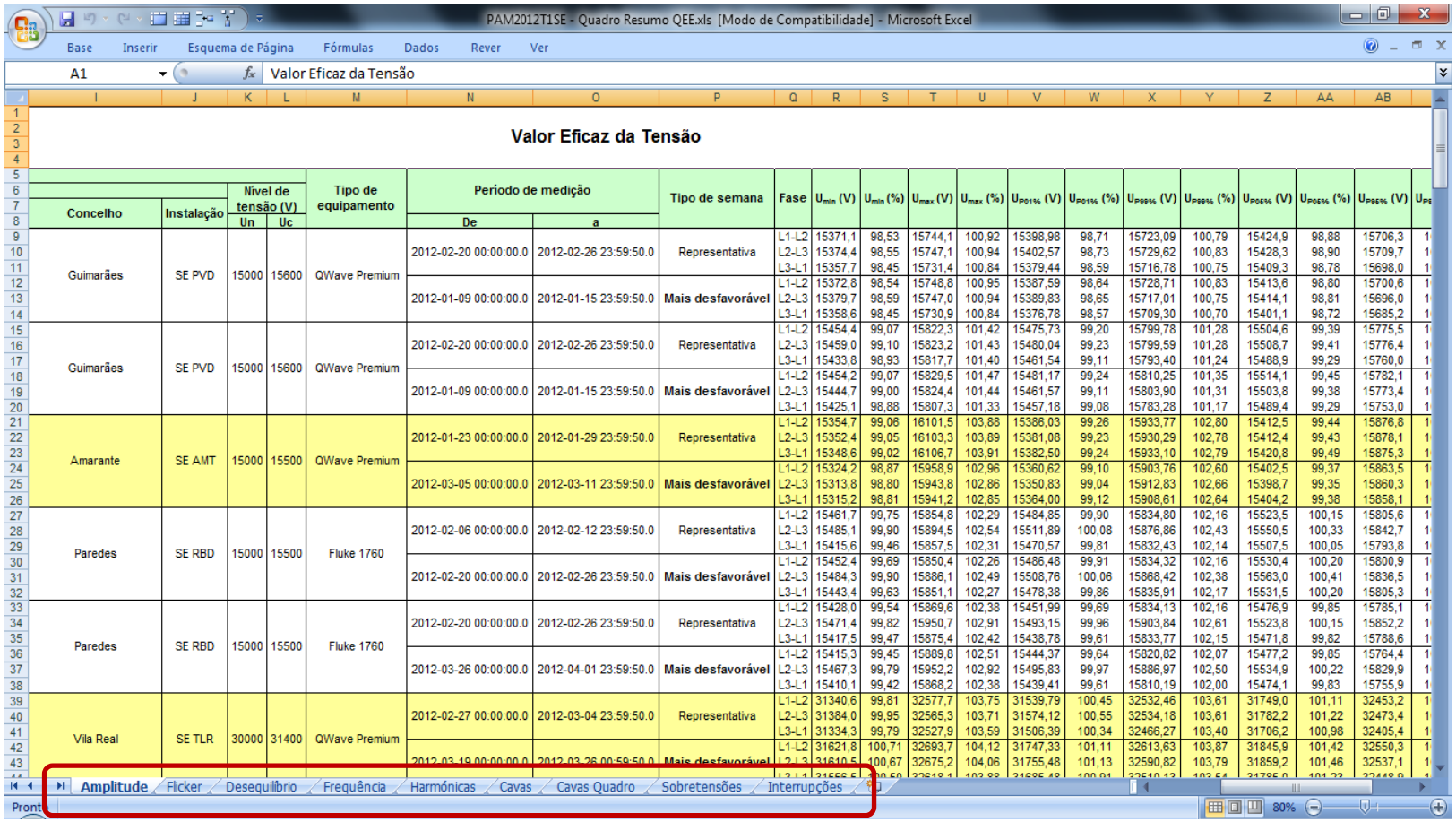
VQ analysis and reporting

Quarterly report to the National Regulator

Sample of VQ Report – Q1 2012 (124 MV and LV busbars)

Published records

- RMS variations
- Flicker
- Unbalance
- Frequency
- Harmonics
- Voltage dips
- DisDip table
- Voltage swells
- Interruptions



PAM2012T1SE - Quadro Resumo QEE.xls [Modo de Compatibilidade] - Microsoft Excel

Base Inserir Esquema de Página Fórmulas Dados Rever Ver

A1 Valor Eficaz da Tensão

Valor Eficaz da Tensão

Concelho	Instalação	Nível de tensão (V) Un	Nível de tensão (V) Uc	Tipo de equipamento	Período de medição De	Período de medição a	Tipo de semana	Fase	U_{min} (V)	U_{min} (%)	U_{max} (V)	U_{max} (%)	$U_{P01\%}$ (V)	$U_{P01\%}$ (%)	$U_{P99\%}$ (V)	$U_{P99\%}$ (%)	$U_{P05\%}$ (V)	$U_{P05\%}$ (%)	$U_{P95\%}$ (V)
Guimarães	SE PVD	15000	15600	QWave Premium	2012-02-20 00:00:00.0	2012-02-26 23:59:50.0	Representativa	L1-L2	15371,1	98,53	15744,1	100,92	15398,98	98,71	15723,09	100,79	15424,9	98,88	15706,3
								L2-L3	15374,4	98,55	15747,1	100,94	15402,57	98,73	15729,62	100,83	15428,3	98,90	15709,7
								L3-L1	15357,7	98,45	15731,4	100,84	15379,44	98,59	15716,78	100,75	15409,3	98,78	15698,0
					2012-01-09 00:00:00.0	2012-01-15 23:59:50.0	Mais desfavorável	L1-L2	15372,8	98,54	15748,8	100,95	15387,59	98,64	15728,71	100,83	15413,6	98,80	15700,6
								L2-L3	15379,7	98,59	15747,0	100,94	15389,83	98,65	15717,01	100,75	15414,1	98,81	15696,0
								L3-L1	15358,6	98,45	15730,9	100,84	15376,78	98,57	15709,30	100,70	15401,1	98,72	15685,2
Guimarães	SE PVD	15000	15600	QWave Premium	2012-02-20 00:00:00.0	2012-02-26 23:59:50.0	Representativa	L1-L2	15454,4	99,07	15822,3	101,42	15475,73	99,20	15799,78	101,28	15504,6	99,39	15775,5
								L2-L3	15459,0	99,10	15823,2	101,43	15480,04	99,23	15799,59	101,28	15508,7	99,41	15776,4
								L3-L1	15433,8	98,93	15817,7	101,40	15461,54	99,11	15793,40	101,24	15488,9	99,29	15760,0
					2012-01-09 00:00:00.0	2012-01-15 23:59:50.0	Mais desfavorável	L1-L2	15454,2	99,07	15829,5	101,47	15481,17	99,24	15810,25	101,35	15514,1	99,45	15782,1
								L2-L3	15444,7	99,00	15824,4	101,44	15461,57	99,11	15803,90	101,31	15503,8	99,38	15773,4
								L3-L1	15425,1	98,88	15807,3	101,33	15457,18	99,08	15783,28	101,17	15489,4	99,29	15753,0
Amarante	SE AMT	15000	15500	QWave Premium	2012-01-23 00:00:00.0	2012-01-29 23:59:50.0	Representativa	L1-L2	15354,7	99,06	16101,5	103,88	15386,03	99,26	15933,77	102,80	15412,5	99,44	15876,8
								L2-L3	15352,4	99,05	16103,3	103,89	15381,08	99,23	15930,29	102,78	15412,4	99,43	15878,1
								L3-L1	15348,6	99,02	16106,7	103,91	15382,50	99,24	15933,10	102,79	15420,8	99,49	15875,3
					2012-03-05 00:00:00.0	2012-03-11 23:59:50.0	Mais desfavorável	L1-L2	15324,2	98,87	15958,9	102,96	15360,62	99,10	15903,76	102,60	15402,5	99,37	15863,5
								L2-L3	15313,8	98,80	15943,8	102,86	15350,83	99,04	15912,83	102,66	15398,7	99,35	15860,3
								L3-L1	15315,2	98,81	15941,2	102,85	15364,00	99,12	15908,61	102,64	15404,2	99,38	15858,1
Paredes	SE RBD	15000	15500	Fluke 1760	2012-02-06 00:00:00.0	2012-02-12 23:59:50.0	Representativa	L1-L2	15461,7	99,75	15854,8	102,29	15484,85	99,90	15834,80	102,16	15523,5	100,15	15805,6
								L2-L3	15485,1	99,90	15894,5	102,54	15511,89	100,08	15876,86	102,43	15550,5	100,33	15842,7
								L3-L1	15415,6	99,46	15857,5	102,31	15470,57	99,81	15832,43	102,14	15507,5	100,05	15793,8
					2012-02-20 00:00:00.0	2012-02-26 23:59:50.0	Mais desfavorável	L1-L2	15452,4	99,69	15850,4	102,26	15486,48	99,91	15834,32	102,16	15530,4	100,20	15800,9
								L2-L3	15484,3	99,90	15886,1	102,49	15508,76	100,06	15868,42	102,38	15563,0	100,41	15836,5
								L3-L1	15443,4	99,63	15851,1	102,27	15478,38	99,86	15835,91	102,17	15531,5	100,20	15805,3
Paredes	SE RBD	15000	15500	Fluke 1760	2012-02-20 00:00:00.0	2012-02-26 23:59:50.0	Representativa	L1-L2	15428,0	99,54	15869,6	102,38	15451,99	99,69	15834,13	102,16	15476,9	99,85	15785,1
								L2-L3	15471,4	99,82	15950,7	102,91	15493,15	99,96	15903,84	102,61	15523,8	100,15	15852,2
								L3-L1	15417,5	99,47	15875,4	102,42	15438,78	99,61	15833,77	102,15	15471,8	99,82	15788,6
					2012-03-26 00:00:00.0	2012-04-01 23:59:50.0	Mais desfavorável	L1-L2	15415,3	99,45	15889,8	102,51	15444,37	99,64	15820,82	102,07	15477,2	99,85	15764,4
								L2-L3	15467,3	99,79	15952,2	102,92	15495,83	99,97	15886,97	102,50	15534,9	100,22	15829,9
								L3-L1	15410,1	99,42	15868,2	102,38	15439,41	99,61	15810,19	102,00	15474,1	99,83	15755,9
Vila Real	SE TLR	30000	31400	QWave Premium	2012-02-27 00:00:00.0	2012-03-04 23:59:50.0	Representativa	L1-L2	31340,6	99,81	32577,7	103,75	31539,79	100,45	32532,46	103,61	31749,0	101,11	32453,2
								L2-L3	31384,0	99,95	32565,3	103,71	31574,12	100,55	32534,18	103,61	31782,2	101,22	32473,4
								L3-L1	31334,3	99,79	32527,9	103,59	31506,39	100,34	32466,27	103,40	31706,2	100,98	32405,4
					2012-03-19 00:00:00.0	2012-03-26 00:59:50.0	Mais desfavorável	L1-L2	31621,8	100,71	32693,7	104,12	31747,33	101,11	32613,63	103,87	31845,9	101,42	32550,3
								L2-L3	31610,5	100,67	32675,2	104,06	31755,48	101,13	32590,82	103,79	31859,2	101,46	32537,1

Amplitude | Flicker | Desequilíbrio | Frequência | Harmónicas | Cavas | Cavas Quadro | Sobretensões | Interrupções

Pronto 80%

About 70 000 records / quarter

VQ analysis and reporting

Quarterly report to the National Regulator

Main challenges	Consequences	Possible approach
Lack of European standardization on VQ reporting (data and format)	**Limitations on comparison of VQ results** between regions/countries Large investments on development of **country-specific reporting tools**	**Definition of a European standard template for VQ data reporting to National Regulators:** Promote the VQ benchmarking between European regions Support for future adjustments in EN 50160 Reference for developers of PQ Management System, making this template broadly available for reporting Reduction of investment in country-specific reporting tools, exportation and integration of data
Each **National Regulator** specifies its **own reporting requirements**		
PQ Management Systems are **proprietary systems,** with limited interaction with third-party systems	Limitations to a true open market of PQ Management Systems	
PQ Management Systems have **limited data exportation features** – Event characterization list typically not included in PQDIF exportation tools	**Limitations to analysis of country events** recorded by several PQ Management Systems	
PQ Management Systems are typically **designed to operate with few recording devices**	**Large investments on exportation and integration of data** from different PQ Management Systems	

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Distribution network optimization

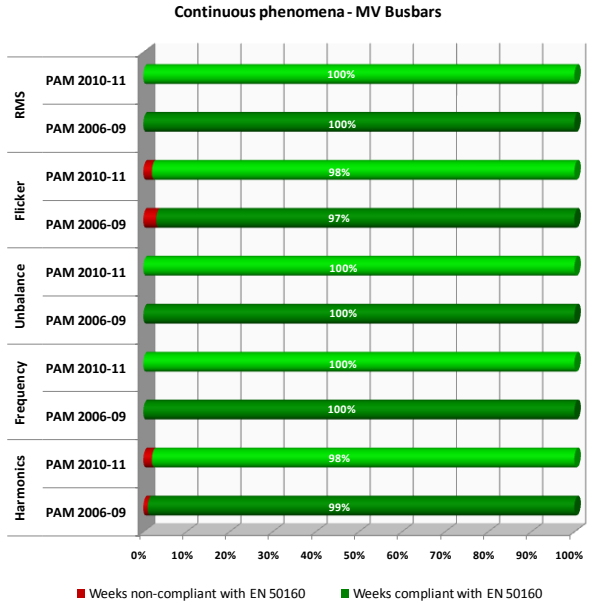
Analysis to support improving actions

Continuous phenomena

- Analysis and reporting of voltage compliance with EN 50160
  - Permanent monitoring in HV/MV substations
  - Rolling monitoring in HV/MV and MV/LV substations
- Definition of actions to reduce root-causes of non-compliant records
  - RMS voltage variations in LV busbars
  - Flicker
  - Harmonics

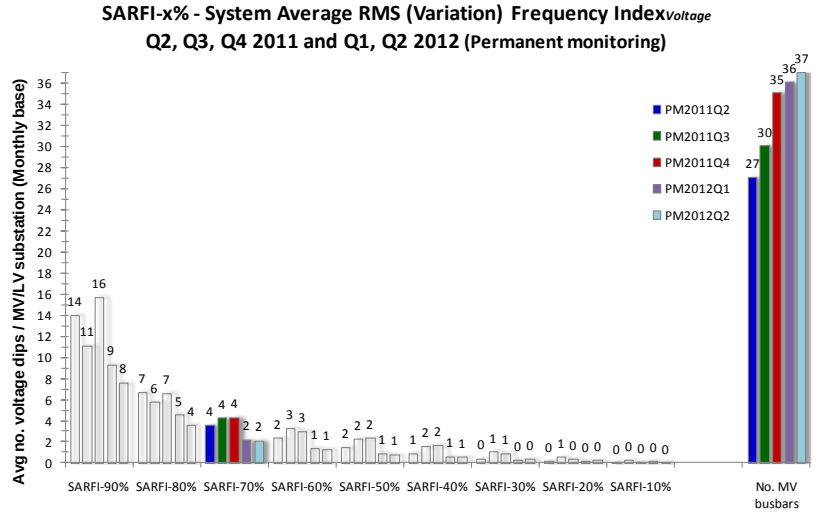
VQ events

- Analysis of voltage dips, swells and interruptions
- Selection of substations for improving actions
  - Computation of an aprox. to SARFI-70% index
  - Busbars with SARFI-70% > 10 events/month → Detailed analysis of root-causes to voltage dips



PAM 2006-09: 539 MV busbars (5819 weeks)

PAM 2010-11: 334 MV busbars (3496 weeks)

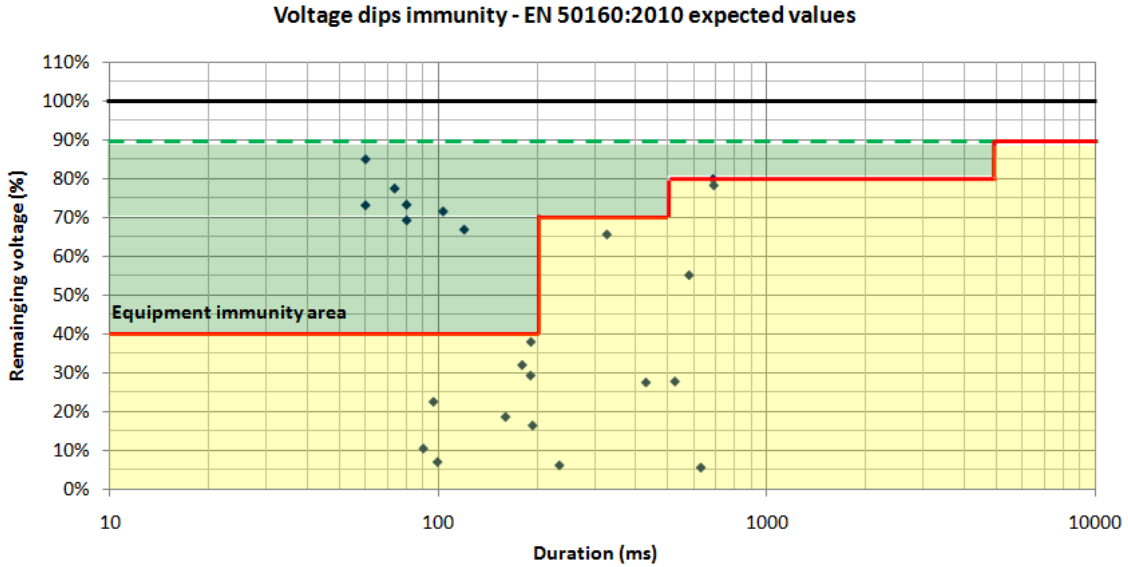


Support to sensitive HV and MV customers

Analysis to support improving actions

Typical approach

- Potential sensitive MV customers invited to report production disturbances during permanent/rolling monitoring campaigns
- PQ monitoring at HV or MV customers entrance with report of production disturbances
- Cause-effect analysis VQ events/reported disturbances
- Voltage dips severity analysis regarding Annex B of EN 50160
- Proposal of solutions to distribution network and customer installation



Analysis based on EN 50160:2010 standard – Expected immunity for Class 3 equipment of IEC 61000-4-11 and IEC 61000-4-34

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PQ management costs

PQ Management Center

- Initial investment – Central servers and PQ Management software (150 000 €)
- Labour costs – 5 persons team

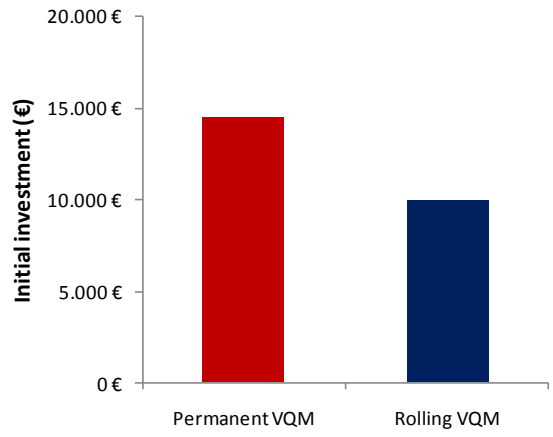
Permanent monitoring

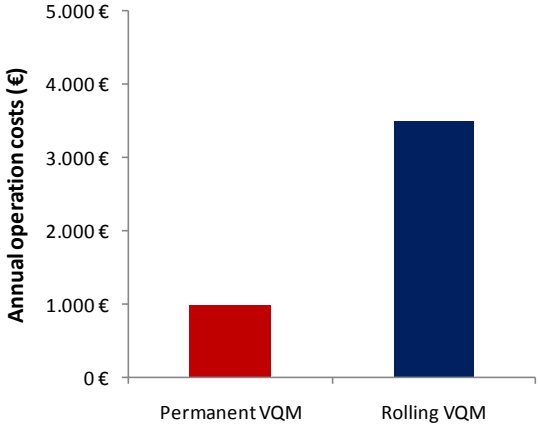
- Initial investment – VQM devices for 1 typical HV/MV substation (2 MV busbars), cabinet, wiring and commissioning (15 000 €)
- Annual operation costs – Calibration, maintenance and communications (1000 €)

Rolling monitoring campaigns (3 months)

- Initial investment – VQM devices for 1 typical HV/MV substation (2 MV busbars) and UMTS communication modules (10 000 €)
- Annual operation costs – Install/uninstall in 4 substations, calibration, maintenance and communications (3500 €)

VQ monitoring costs
Permanent / Rolling Monitoring





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Thank you very much!

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