Experience with VQM in Italy
From demonstration to regulation

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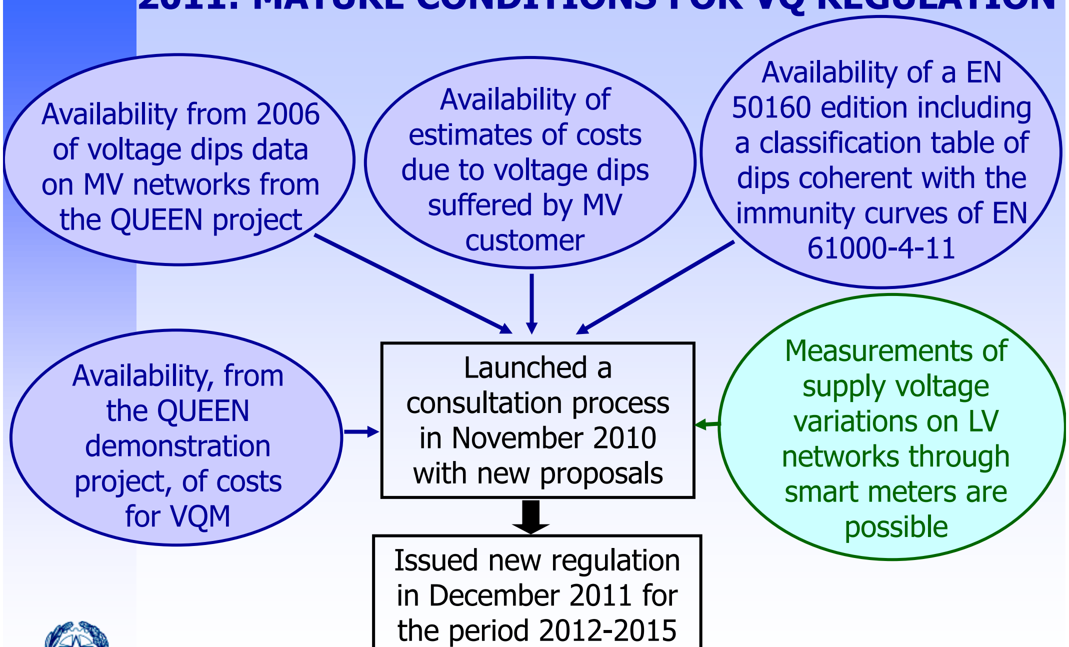
EVOLUTION OF THE REGULATION

	2000-2003	2004-2007	2008-2011	2012-2015
SAIDI – CMLs (avg. Duration)	Incentives / penalties	Incentives / penalties	Incentives / penalties	Adjusted incentives / penalties
Multiple interr. (max numb., MV)	*Monitoring numb. interr. (per single MT cust.)*	Guaranteed standard *(only long interr.)*	Stricter guarant'd standard *(only long interr.)*	Stricter guarant'd standard *(long+short interr.)*
SAIFI – CIs (avg. number)	*Monitoring num. long int.*	*Monitoring num. both long & short*	Incent./penalties *(SAIFI+MAIFI)*	Incent./penalties *(SAIFI+MAIFI)*
Very long interr. (max durat, LV-MV)		*Consultation and statistic research*	Guarant'd stds (incl.except.events)	Guarant'd stds (incl.except.events)
Quality of Transm. service		*Monitoring transmission*	Incent./penalties. (ENS)	Rev.incentives/penalties. (ENS)
Voltage quality	*Std. on supply voltage variations for MV and LV consumers*	*Launched VQM on HV-MV networks* *Individual VQ verification for HV and MV consumers*	*Start VQM on LV. Avail. of MV dips data, costs (cust. costs due to dips; VQM costs) New 50160*	*Towards Regulation: dips (MV) - voltage variations (LV)*

VOLTAGE QUALITY REGULATORY FRAMEWORK

- 2000: introduced a std. (overall until 2003, now guaranteed) on the verification of supply voltage variations under request of MV or LV consumers
- 2004: introduced the individual measurement of voltage quality, according to EN 50160 and EN 61000-4-30, for HV and MV consumers and self-producers
- 2004: introduced quality contracts (individual measurements can be used to draw up quality contracts with DSOs/suppliers (discipline under review)
- 2004/2005, HV: launched a VQ monitoring campaign on HV networks (MONIQUE project, around 165 monitored points)
- 2005, MV: launched the VQ monitoring campaign on MV networks (QUEEN project - 400 fixed MV busbars of HV/MV substations (10%) representing statistically the overall Italian MV network)
- 2006, LV: requested the capability for smart meters to record supply voltage variations according to EN 50160
- 2009, LV: requested to major DSOs a measurement campaign of supply voltage variations through a sample of smart meters (repres. statist. the LV net.)
- 2011, MV and LV: new dispositions for the period 2012-2015

2011: MATURE CONDITIONS FOR VQ REGULATION



2012-2015: MONITORING AND RECORDING OF VOLTAGE DIPS

Obligation for each DSO to equip 100% of MV busbars of HV/MV substations with VQM devices compliant with EN 61000-4-30 within 31st December 2014

For each MV busbar DSOs shall record:

- For each voltage dip:
  - progressive number (in the year)
  - involved phases
  - beginning instant (date; hh:mm:ss:centiss)
  - duration (date; hh:mm:ss:centiss)
  - residual voltage
  - origin (HV or MV)

2012-2015: MONITORING AND RECORDING OF VOLTAGE DIPS

- Summary of recorded dips in a year, separately for origin (HV or MV):
  - number of dips according to the classification table of EN 50160 with chromatic evidence of the immunity curves class 2 and 3 (EN 61000-4-11 and EN 61000-4-34)
  - number of dips below the immunity curve class 2
  - number of dips below the immunity curve class 3

Tensione residua *u* [%]	**Durata *t*** [ms]				
	$10 \leq t \leq 200$	$200 < t \leq 500$	$500 < t \leq 1\,000$	$1\,000 < t \leq 5\,000$	$5\,000 < t \leq 60\,000$
90 > *u* ? 80	CELLA A1	CELLA A2	CELLA A3	CELLA A4	CELLA A5
80 > *u* ? 70	CELLA B1	CELLA B2	CELLA B3	CELLA B4	CELLA B5
70 > *u* ? 40	CELLA C1	CELLA C2	CELLA C3	CELLA C4	CELLA C5
40 > *u* ? 5	CELLA D1	CELLA D2	CELLA D3	CELLA D4	CELLA D5
5 > *u*	CELLA X1	CELLA X2	CELLA X3	CELLA X4	CELLA X5

Separation of responsabilities for voltage dips → (awareness)

2012-2015: PUBLICATION OF DATA

1. DSOs shall publish voltage dips data according to future dispositions by the Autorità
2. The Autorità will publish voltage dips data, in a comparative way as well (e.g.: DSOs vs DSOs, North vs South, urban zones vs rural zones, etc.)

2012-2015: REPORTING VOLTAGE DIPS DATA TO THE AUTHORITY

1. Each DSO shall allow the Autorità to access its VQ data in a "super-user" way (DSOs must make available dips data in a unique and common data format - specified in July 2012 by an ad-hoc working group)
2. DSOs shall report voltage dips data to the Autorità according to future dispositions by the Autorità

2012-2015: REPORTING VOLTAGE DIPS DATA TO MV USERS

1. Voltage dips data shall be reported yearly to MV users according to the recording rules previously presented (see slide no. 5 and 6) once the VQM device on the MV busbar feeding the user is commissioned
2. Historical (expected) levels of voltage dips data shall be reported to MV users requesting new connections or re-activations of existing connections, according to future dispositions by the Autorità

STILL TO DO FOR VOLTAGE DIPS

- Choice of an aggregated indicator. Explored some options in 2011:
  - Discrete Severity Index (DSI)
  - Missing Voltage Time (MVT)
  - Missing Voltage Time Area (MVTA)

  Weighting effect

  - Regulated Dip Frequency (R-DFI) and Regulated System Average Dip Frequency Index (R-SADFI)
  - Number of dips (N): all, below the immunity curve 2, below the immunity curve 3

  Counting effect
- Identification of a regulation scheme

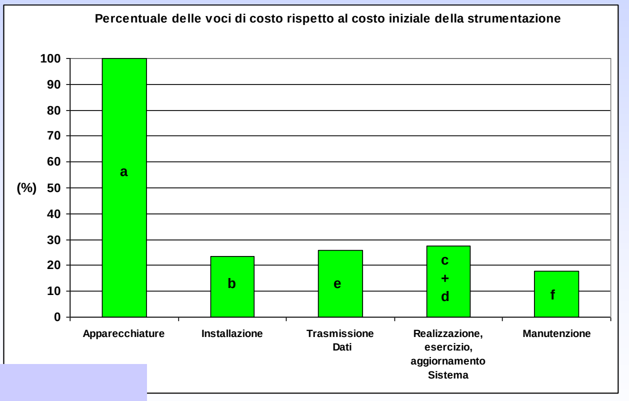
2005-2009 COSTS OF THE QUEEN PROJECT

Investment costs:

a) 400 VQM devices class B (->S)
b) VQM devices installation
c) central system commissioned (ready for recording and reporting)

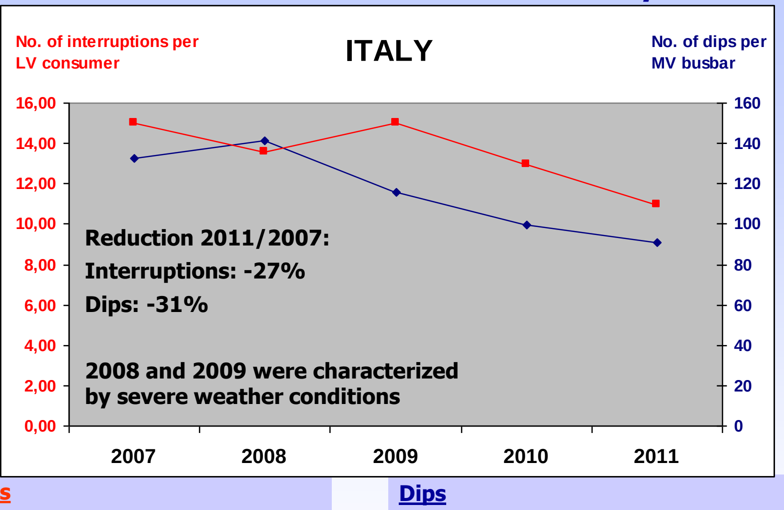
Operating and maintenance costs:

d) central system operation and update
e) data transmission from VQM devices to the central system
f) central system and VQM devices HW/SW maintenance



a) = 0.76 M€
a)+ b)+c)+d)+e)+f) = 1.5 M€
Discount rate = 2.13%

CORRELATION INTERRUPTIONS/DIPS



Interruptions

Causes: all

Origins: EHV-HV-MV

Types of interruptions: unplanned L, S, T

Interr. recording systems: data from each EHV, HV and MV line, yearly reported to the Autorità

Dips

Origins: EHV-HV-MV

Dips recording system: QUEEN (data from 10% of MV busbars of HV/MV substations statistically representing the overall MV network)

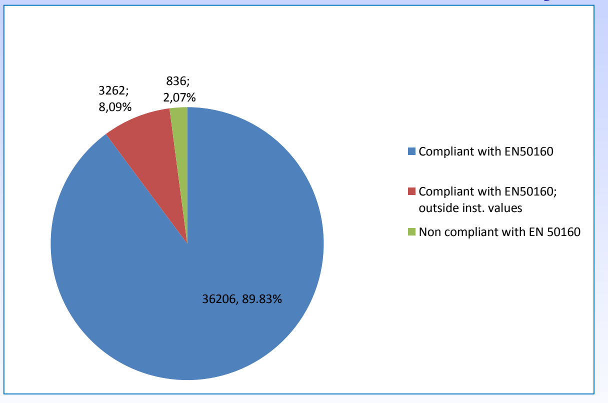
LV: FOCUS ON VOLTAGE VARIATIONS

Data from the measurement campaign of supply voltage variations (1 week in middle January 2010) on LV networks through a **sample of smart meters** are available from major DSOs

Collected data from 55452 smart meters

Some bad data discarded

Analysis done by Politecnico di Milano based on data from 40304 smart meters



2.07% of non compliancy: 2.79% in urban zones, 1.84% in sub-urban zones, 1.85% in rural zones

Normally in one year around 0.005% of LV consumers request the individual verification of supply voltage variations

LV: REGULATION PERSPECTIVES (proposed in November 2010)

1. Determination by the Autorità of a max annual percentage, differentiated per density (urban, suburban, rural), of LV connection points with voltage variations outside tolerance, to be guaranteed by each DSO, and penalization in case this percentage is not met (useful information to DSOs in planning networks)
2. Like 1, but with voltage variations severely outside tolerance (e.g.: no. of 10 minutes intervals with voltage variations non compliant to +/-10%; useful for DSOs to solve problems)
3. Correlation of complaints of consumers to DSOs/suppliers with complaints of consumers to manufactures of appliances (PC, printers, etc.)

CONCLUSIONS

- The QUEEN project (MV/dips) has shown that the transition from demonstration to implementation is feasible
- The opportunity to start measuring supply voltage variations at each LV withdrawal/injection point through smart meters has been caught by the Autorità
- The Autorità decided to focus on dips for MV and supply voltage variations for LV:
  - dips (and transient interruptions) in MV cause around 800 M€/year costs to the Italian economy (around 0.05% of the GDP)
  - convergent regulatory schemes for dips and interruptions are possible
  - the need to supply LV consumers according to EN 50160 for voltage variations will imply, indirectly, compliancy with EN 50160 for MV consumers

Thank you for your attention!

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QUENN project
52 weeks: 3 January 2011 - 1 January 2012
353 MV busbar of HV/MV substations
Average no. of dips per MV busbar

		Durata buchi				
		20-200 ms	200-500 ms	500-1000 ms	1-5 s	5-60 s
T. residua [%]	80...90	31.4	7.9	1.6	1.3	0.5
	70...80	13.3	3.7	0.5	0.2	0.0
	40...70	17.5	5.0	0.3	0.1	0.0
	5...40	5.9	1.5	0.2	0.0	0.0
	1...5	0.0	0.0	0.0	0.0	0.0

http://queen.erse-web.it/

NO OF VQM DEVICES (AdM) PER REGION AND REGIONAL AND NATIONAL AVERAGE VALUES OF THE AGGREGATED VOLTAGE DIPS INDICATORS PROPOSED IN 2011 (YEAR 2009)

Regione	AdM	N	N2a	N3b	DSI_2a	DSI_3b	MVT	MVT2	MVT3	MVTA_2	MVTA_3
Emilia R.	23	36,94	12,97	3,71	36,41	19,58	1,18	0,79	0,46	1,53	1,35
Lombardia	65	43,94	15,98	4,93	43,33	23,02	1,50	1,06	0,55	1,26	1,03
Trentino A.A.	12	56,21	20,17	9,66	62,85	35,55	2,29	1,45	0,92	3,71	1,29
Piemonte	34	66,50	21,95	8,48	65,34	35,81	2,56	1,62	0,94	3,43	2,40
Toscana	28	63,21	24,10	8,49	66,96	36,22	2,41	1,61	0,89	1,85	1,51
Sardegna	14	80,58	24,46	6,55	70,07	39,16	2,68	1,52	0,69	2,37	1,44
Veneto	31	65,63	30,00	10,81	72,13	39,37	2,91	2,29	1,24	3,59	3,05
Valle d'Aosta	4	59,23	32,31	8,46	70,57	39,51	2,76	1,99	0,89	3,85	1,54
Umbria	6	100,51	32,88	6,78	92,87	56,08	4,48	2,40	1,02	3,90	3,56
Marche	18	91,71	33,31	10,06	86,59	49,82	3,53	2,31	1,11	2,86	2,40
Molise	4	113,00	42,50	13,50	98,84	64,23	5,26	2,97	1,59	4,00	3,50
Lazio	28	115,09	43,02	13,74	116,87	65,16	4,60	3,11	1,65	4,45	3,25
Liguria	14	117,93	44,50	11,86	113,90	61,73	4,18	2,94	1,54	4,93	4,71
Friuli V.G.	13	94,52	45,38	22,80	122,16	67,95	4,28	3,06	2,02	4,62	3,98
Abruzzo	11	117,25	50,55	20,46	131,97	77,62	6,06	4,01	2,45	8,17	5,50
Puglia	21	140,00	61,14	24,48	150,18	87,60	6,63	4,98	3,09	12,14	10,75
Basilicata	8	223,25	99,63	35,00	276,63	156,76	15,78	12,25	7,55	44,63	10,38
Campania	29	244,62	111,64	40,63	273,13	162,12	13,76	10,19	5,91	25,63	15,24
Calabria	13	305,55	125,39	50,94	329,45	205,15	17,75	11,81	7,06	33,67	16,56
Sicilia	24	342,27	195,82	88,59	441,52	267,02	22,22	17,78	11,67	42,68	31,41
Media Italia	**400**	**114,45**	**49,63**	**18,81**	**125,72**	**72,86**	**5,71**	**4,13**	**2,45**	**13,62**	**10,36**

N2a, DSI_2a, MVT2, MVTA_2: with reference to the immunity curve class 2
N3b, DSI_3b, MVT3, MVTA_3: with reference to the immunity curve class 3

ESTIMATES OF MV CUSTOMER COSTS DUE TO DIPS AND TRANSIENT INTERRUPTIONS

Direct costs per event (process halt) per kW

[€/kW-event]	Entire sample (sub-sample)		
	Median	**Mean**	**Interval**
All sectors	**0.8 (1.1)**	**2.9 (3.4)**	**0 (0.1) - 31**
Per NACE codes			
DA – Food products	0.6	6.1	0.2 – 31
DB – Textiles	3.3	3.3	3.3
DE – Paper	0.8 (0.9)	0.9 (1.0)	0.1 – 2.3
DF – Refined petroleum products	13.7	13.7	13.7
DG – Chemicals and man-made fibres	0.6 (0.7)	0.5 (0.7)	0 (0.6) – 0.8
DH – Plastic products	1.9	2.3	0.1 – 4.3
DI – Glass and ceramic products	0.8	0.9	0.1 – 2.4
DJ – Metals products	1.1 (5.1)	3.4 (5.1)	0 (1.1) – 9.0
DL – Electrical equipment	9.6	10.9	0.1 – 23.1
DM – Auto and auto components	3.0	3.0	0.7 – 5.2

Source: study carried out by Politecnico di Milano in 2006

TOTAL ANNUAL COSTS FOR THE ITALIAN ECONOMY DUE TO DIPS AND TRANSIENT INTERRUPTIONS ON MV NETWORKS

- Annual direct costs for the Italian economy

[Mln €/year]	Annual direct costs	
	(Median)	(Min-Max)
OSS	276.4	260.2 – 305.9
USS	325.8	-
OSS + USS	602.2	586.0 – 631.6

- Annual indirect costs for the Italian economy: 203.2 Million €/year
- Total annual costs for the Italian economy

[Mln €/year]	Annual total costs	
	(Median)	(Min-Max)
Direct costs OSS + Indirect costs	479.6	463.4 – 508.9
Direct costs OSS and USS + Indirect costs	805.4	789.2 – 834.7

Source: study carried out by Politecnico di Milano in 2006

PREREQUISITES FOR A GOOD REGULATION

- Identification of objectives
- Availability of measuring/recording rules and indicators
- Reference to technical standards, where available and possible
- Provisions on exclusion clauses
- Preliminary availability of data
- Awareness of consequences for the society in absence (and in presence) of the regulation
- Need to consult stakeholders before taking decisions
- Implementation through gradual mechanisms
- Measurability of regulation results