Experience with VQM in Italy

Ferruccio Villa
AEEG
Head of Electricity Quality of Supply
fvilla@autorita.energia.it

Michele de Nigris
ERSE
Director - Dpt T&D Technologies
michele.denigris@erse-web.it

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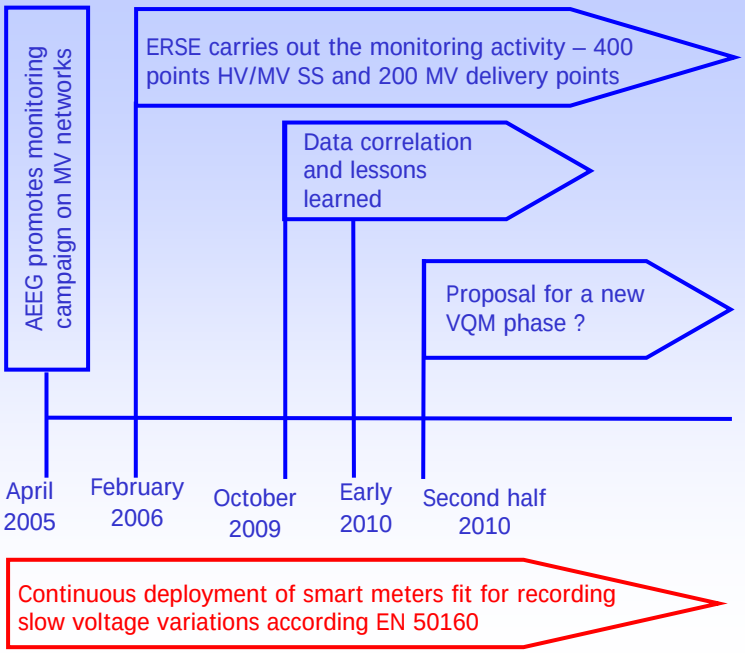
CHRONOLOGY



2005: OBJECTIVES BEHIND THE MONITORING CAMPAIGN

Knowledge of the performances of the MV networks and publication of them	
Making aware customers about tools that quality regulation makes available to them (quality contracts, individual measurements)	
Correlation of measured data to the structure of the network, power of HV/MV transformers, short circuit power at delivery points, load characteristics, presence of disturbing loads, presence of distributed generation	
Assess responsibilities, as far as possible	
Assess the possibility of introducing measurement obligations for DNOs and then a financial regulation of some PQ indicators	
Make use of the results of the monitoring campaign in order to confirm or revise limit values of PQ indicators so that they can reflect the characteristics of the Italian electrical system	

PUBLICATION OF VQ DATA

- VQ data are available on-line on: http://queen.ricercadisistema.it
- Some data (in particular regarding dips) were published in the 4th Ceer Benchmarking Report on Quality of Electricity Supply

Residual Vr [%]	Duration (ms)					
	20 - 200	200 - 500	500 - 1.000	1.000 - 5.000	5.000 - 60.000	Total
80 - 90	37,7	5,5	1,1	0,9	0,1	45,3
70 - 80	19,9	4,1	0,5	0,2	0	24,7
40 - 70	38,8	6,6	0,6	0,2	0,1	46,3
5 - 40	12,5	2,6	0,3	0,1	0	15,5
0 - 5	0,3	0	0	0	0	0,3
Total	109,2	18,8	2,5	1,4	0,2	132,1

Italy, Year 2007, all types of MV networks, MV bus-bars of HV/MV substations

Yellow cells: equipment immunity class 2
Yellow + Green: equipment immunity class 3
Red line: compatibility curve

MONITORING UNITS INSTALLED

400 monitoring units
(they monitor about 10% of the MV bus-bars of the MV distribution network).

The sample is representative of the network characteristics in terms of:

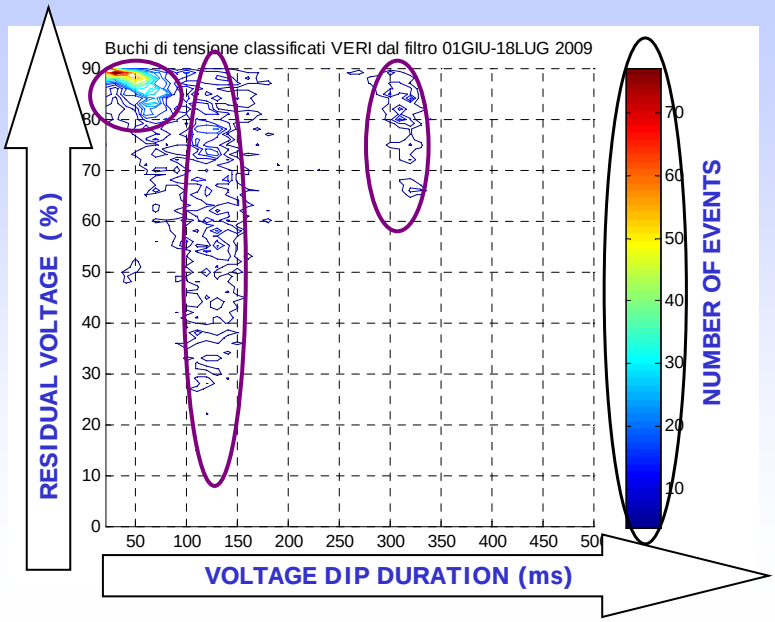
- number of HV/MV substations in each region
- length of the MV lines
- type of MV lines: cable, overhead, mixed
- neutral compensation or isolated neutral
- number of MV customers
- density of LV customers

73 owned by as many MV customers who decided to voluntarily (with the promotion of the Authority) participate to the monitoring campaign

124 owned by Distribution Network Operators

This sample of units is not statistically representative of the monitored MV network

ROUGH RESULTS – VOLTAGE DIPS



WHAT DID WE LEARN IN 3 YEARS OPERATION ?

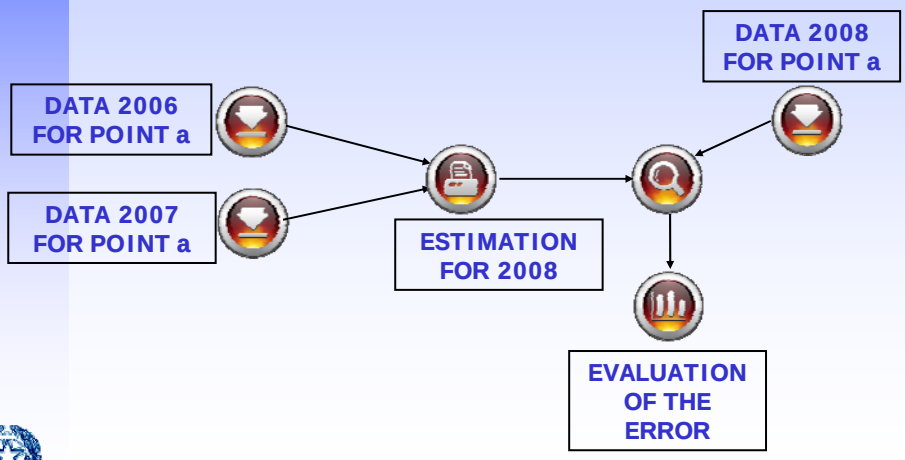
MEASURING SYSTEM	• Voltage sensors: in HV/MV substation PH-GR sensors (VTs) is most common • Specific connection and saturation of VTs may generate “false positive” events mainly in case of 1-ph-gr faults especially on Isolated neutral network portions. (~30% events) • Need of filtering algorithm to get rid of false positives (or change of sensors ..)
SYSTEM MANAGEMENT	• Instrument cost is marginal with respect to implementing M&O costs • Customized solutions are necessary • Continuous maintenance and updating

WHAT DID WE LEARN IN 3 YEARS OPERATION ?

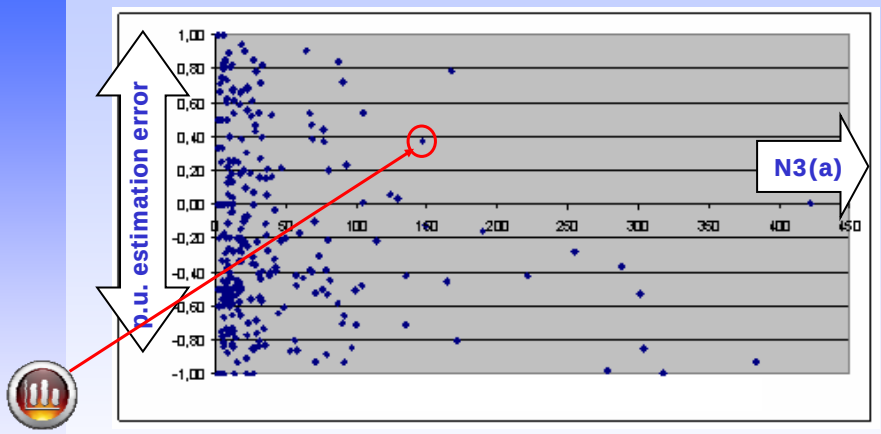
DATA ANALYSIS	• HV/MV station observation point is suitable to monitor what happens downstream (for dips) • Monitoring campaign shall cover several years as there is a wide variability of data on the single site in consecutive years • The single measurement point dip-performance shows high variability year after year • Nationwide, the dip-performance shows stable trends (variations 2-3% over the years) • About 30% of the events are transferred from HV networks • Multiple linear regression models are necessary to analyze the data and derive learning

CAN I ESTIMATE THE VOLTAGE-DIP PERFORMANCE FOR NEXT YEAR IN A SPECIFIC POINT ?

SUPPOSE I WANT TO ESTIMATE THE VALUE OF THE VOLTAGE DIP FOR 2008 BASED ON THE AVERAGE VALUE OF 2006-2007 ON THE SAME MEASURING POINT



CAN I ESTIMATE THE VOLTAGE-DIP PERFORMANCE FOR NEXT YEAR IN A SPECIFIC POINT ?



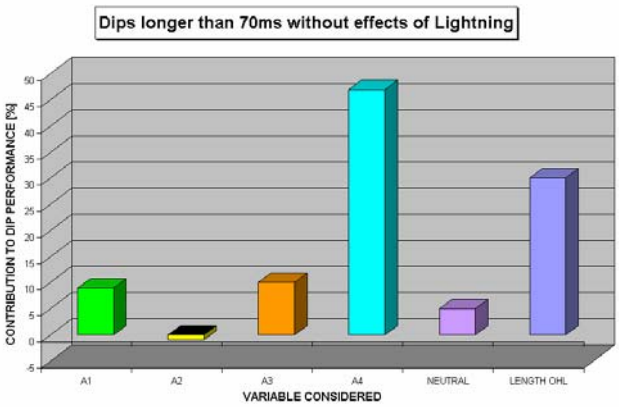
Error that would have been done in estimating the expected number of dips in 2008 starting from the actual number of dips of 2006-2007

1 point = 1 measuring location

LEARNING FROM THE MULTIPLE LINEAR REGRESSION

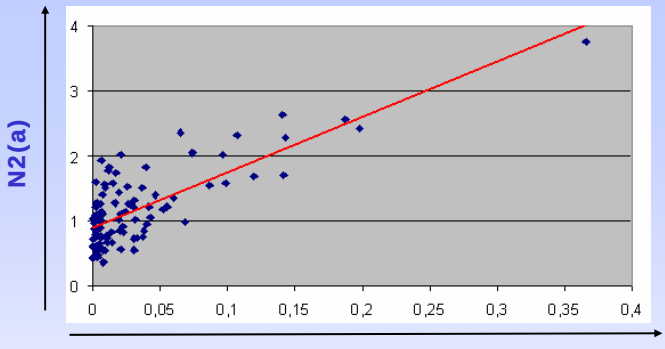
MLR	• Allows to analyze data dividing variables between influencing/not relevant and to quantify the contribution of each variable independently of all others. Factors having high influence: • Geographical aspects • Length of overhead lines • Neutral operation (isolated vs. compensated) Factors having little influence • Length of underground cables • System voltage Factors needing more precise data • Lightning

GEOGRAPHICAL ASPECTS



- **DIFFERENCES IN DIP PERFORMANCES ARE INDEPENDENT FROM ALL OTHER PARAMETERS -> LINKED WITH OTHER FACTORS (ASSET MANAGEMENT?)**
- **INTERESTING FOR THE DISTRIBUTOR TO INVESTIGATE POTENTIAL ASPECTS NOT LINKED WITH NETWORK STRUCTURE AND FIND APPROPRIATE SOLUTIONS**

LIGHTNING



- **THERE IS APPARENTLY A VERY GOOD CORRELATION BETWEEN LIGHTNING ACTIVITY TO GROUND Ng AND THE DIP PERFORMANCES N2(a)**
- **MLR REVEALS THAT:**
  - **THE REAL DATA IS STRONGLY BIASED BY THE GEOGRAPHICAL ASPECTS**
  - **Ng DOES NOT MODIFY THE DIFFERENCES BETWEEN THE AREAS**
  - **La IS SUFFICIENT TO CONSIDER LIGHTNING AND ALL OTHER EVENTS CAUSING LINE FAULTS**

RESULTS OF THE MONITORING CAMPAIGN VS. OBJECTIVES

Knowledge of the performances of the MV networks and publication of them	☑
Making aware customers about tools that quality regulation makes available to them (quality contracts, individual measurements)	☒
Correlation of measured data to the structure of the network, power of HV/MV transformers, short circuit power at delivery points, load characteristics, presence of disturbing loads, presence of distributed generation	☑
Assess responsibilities, as far as possible	EN 50160
Assess the possibility of introducing measurement obligations for DNOs and then a financial regulation of some PQ indicators	New consultation phase in 2010
Make use of the results of the monitoring campaign in order to confirm or revise limit values of PQ indicators so that they can reflect the characteristics of the Italian electrical system	☑

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