PQ Benchmarking in the Era of the Smart Grid

Bill Howe, PE
Electric Power Research Institute
Program Manager, Power Quality

EPRI ELECTRIC POWER RESEARCH INSTITUTE

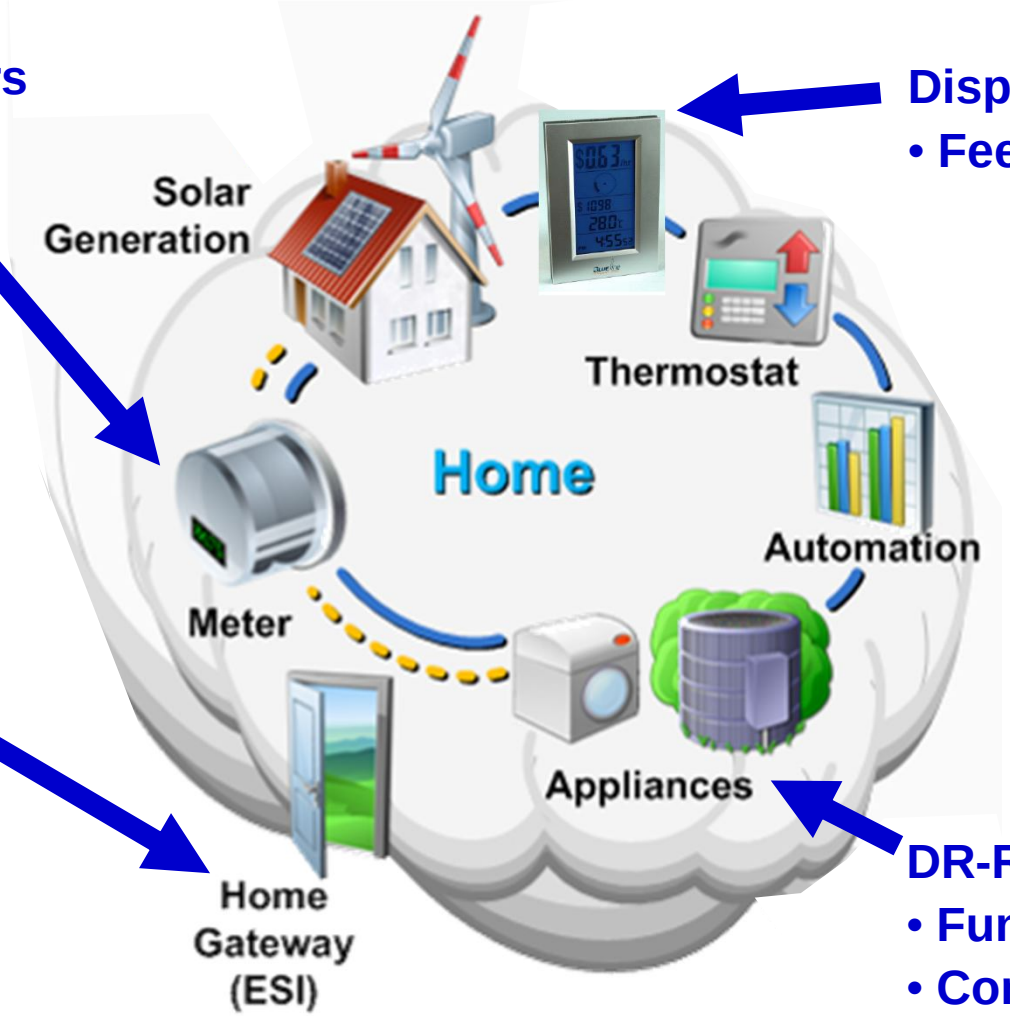
Is Smart Grid going to Eliminate Power Quality as an issue?

"You must be worried about Smart Grid … it's going to eliminate the need for PQ, right?"

Smart Grid: Increasing Grid Complexity

Advanced Meters
- Energy Mgmt
- Security

Gateways
- Custom Box
- Smart Circuit Breaker Panel
- PC/Router



Display Device
- Feedback Effect

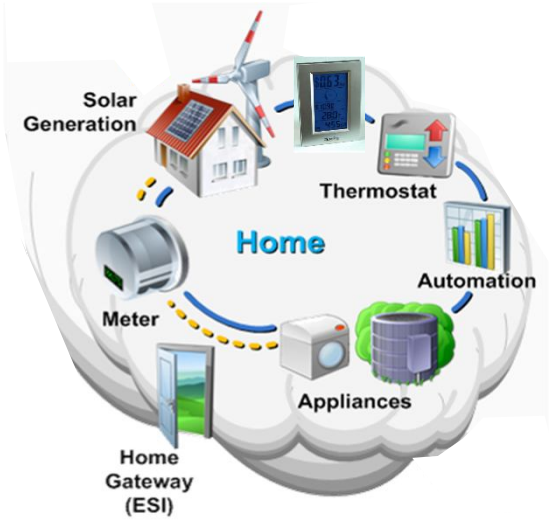
DR-Ready Appliances
- Functional Specs
- Communications

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Smart Grid: Increasing Grid Complexity

- Increased grid automation
- Increase number of grid-connected power supplies and devices
- Proliferation of grid-interactive loads
  - Rooftop PV
  - Energy storage
  - Electric vehicle chargers
- Close-coupling of new loads increases the chance for interaction
- Increased deployment of frequency-sensitive loads (capacitors)
- New grid configuration and operating strategies

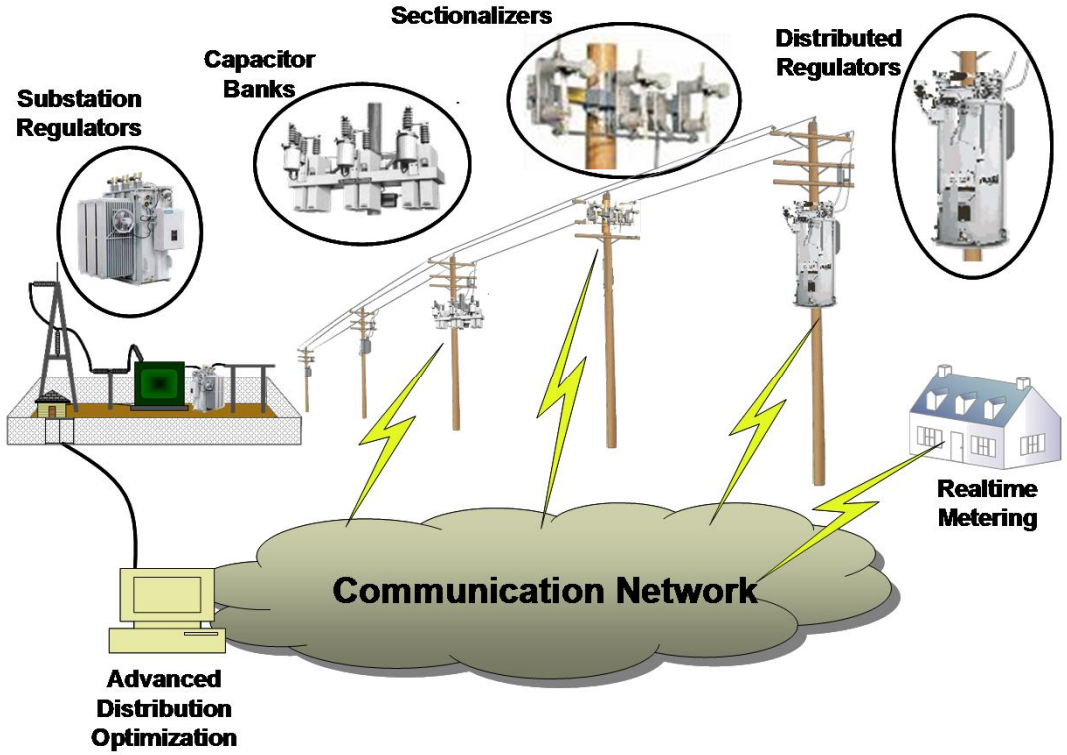
Change and increased complexity inexorably leads to new, unforeseen challenges



EPRI ELECTRIC POWER RESEARCH INSTITUTE

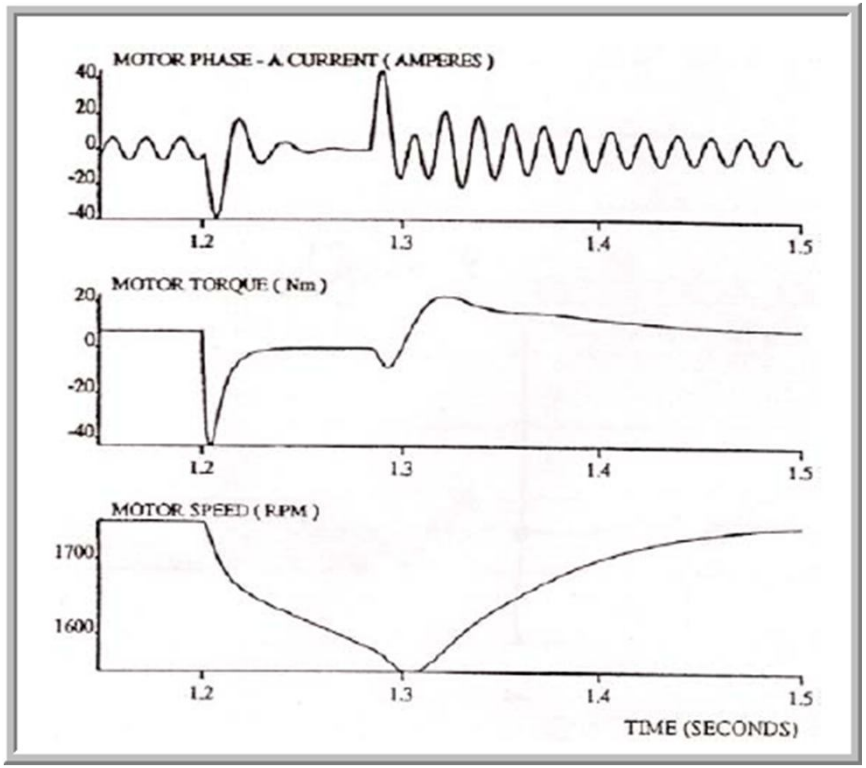
Distribution Energy Efficiency Program (DEEP)
Volt/VAR Support

- **Research Need**: Understanding the impact on transients and resonance from large deployments of switched capacitors



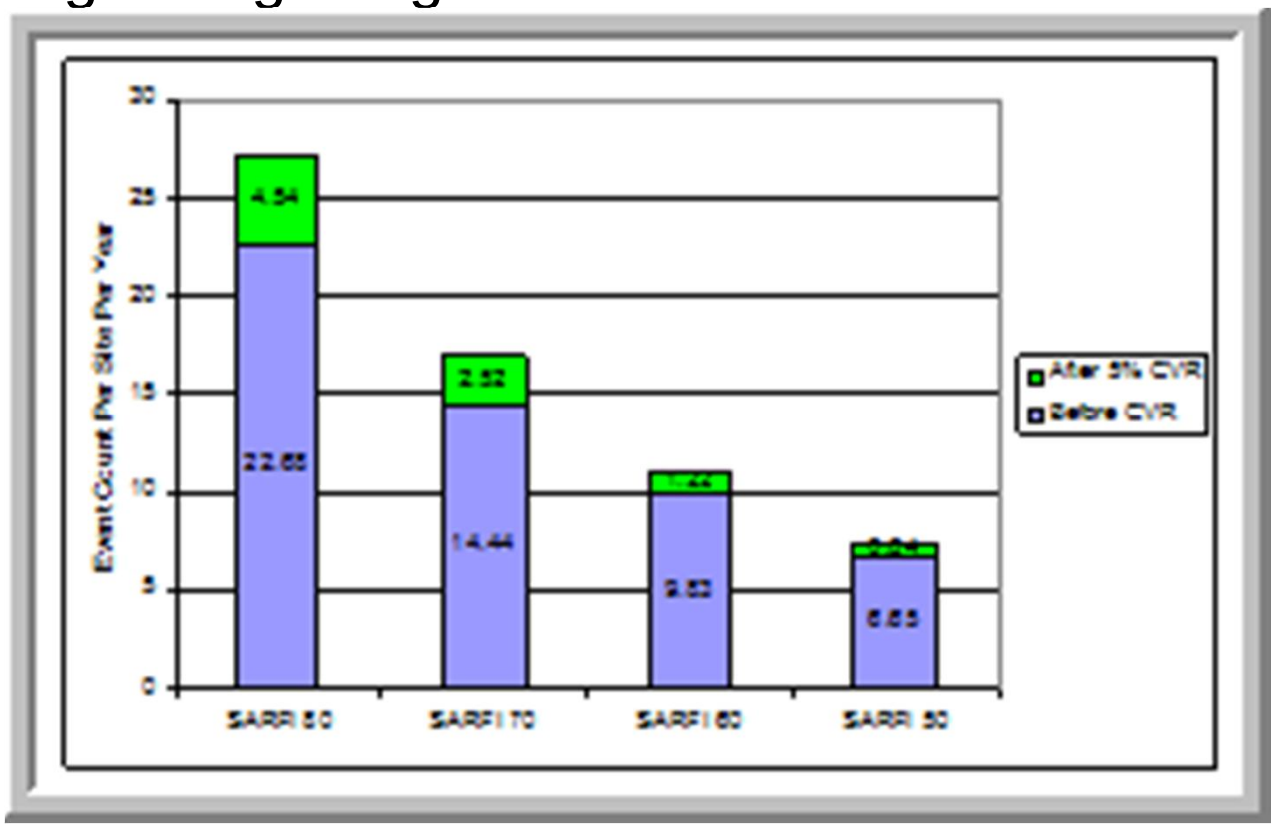
Important Customer Sensitivity Issues (cont.)

- **Research Need**: Understanding equipment behavior under changed operating conditions, especially motors operating at reduced steady state voltage.



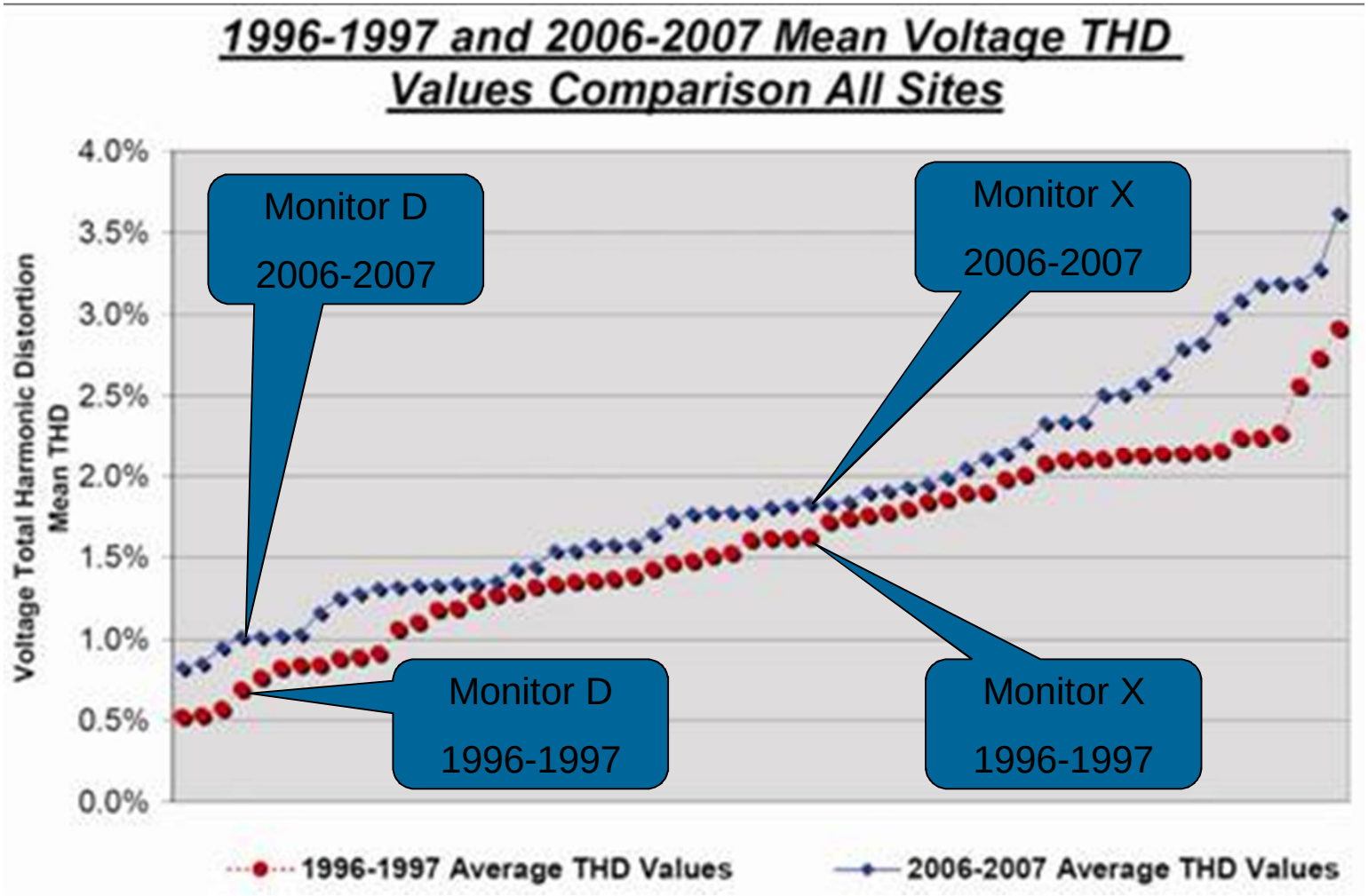
Important Customer Sensitivity Issues

- **Research Need**: Ensuring that reduced nominal voltage doesn't result in increased customer process interruptions during voltage sag events



EPRI ELECTRIC POWER RESEARCH INSTITUTE

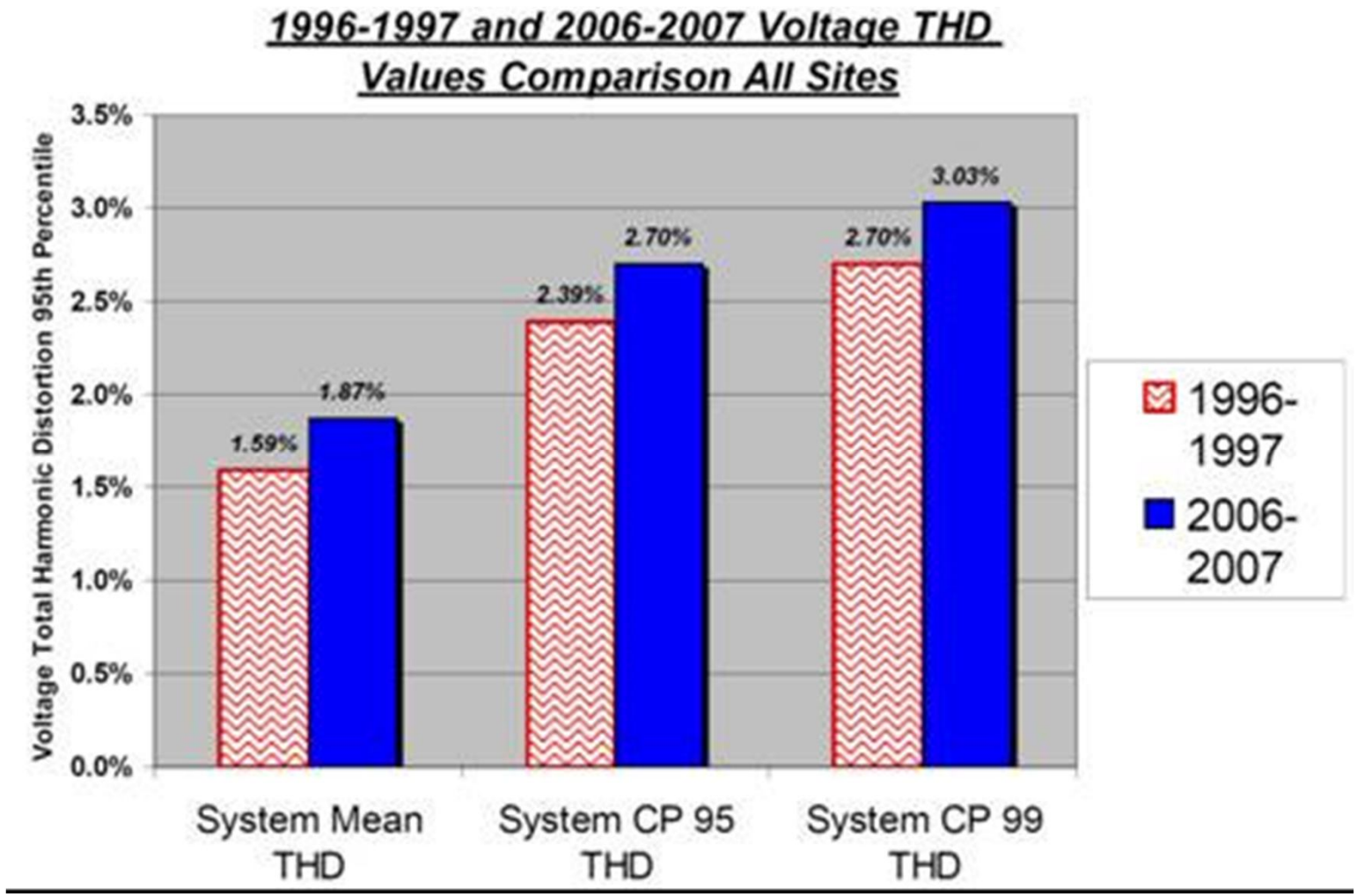
Are Harmonic Levels on T&D Systems Changing?
Direct Evidence Source from a large N.A. utility



Each “colored dot” represents one monitor on the secondary distribution system .

The “blue dot” directly above t he “red dot” is the same monitor point “ten years later”

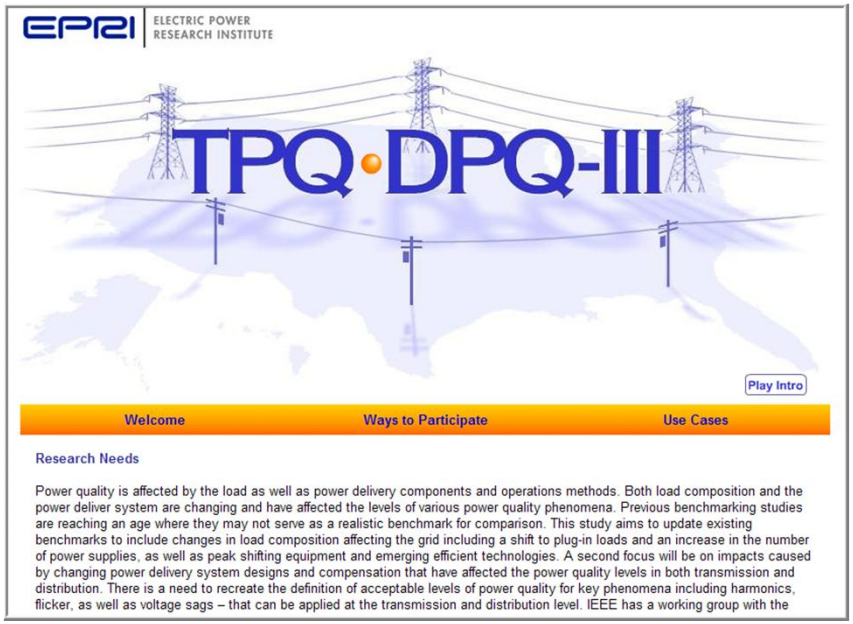
Are Harmonic Levels on T&D Systems Changing?



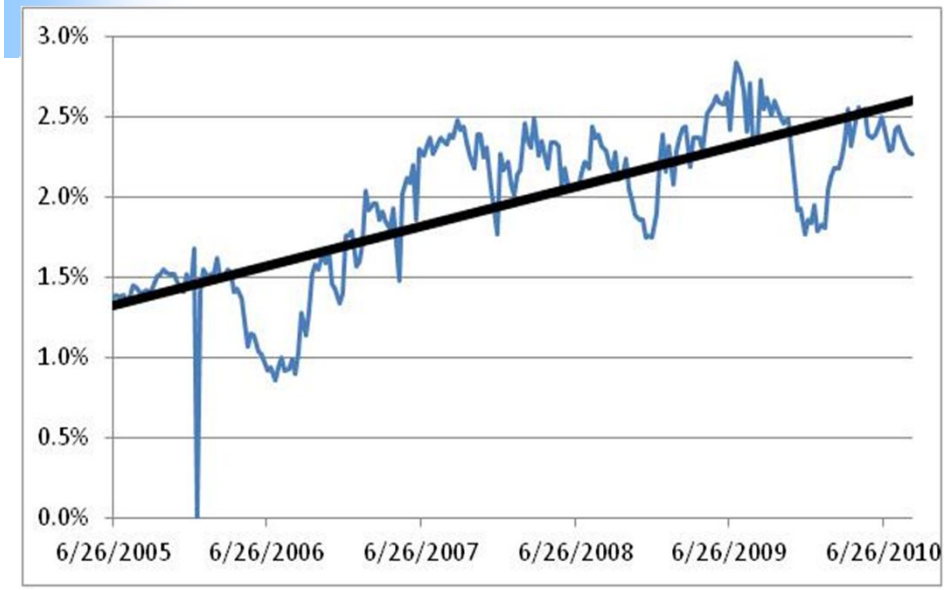
EPRI ELECTRIC POWER RESEARCH INSTITUTE

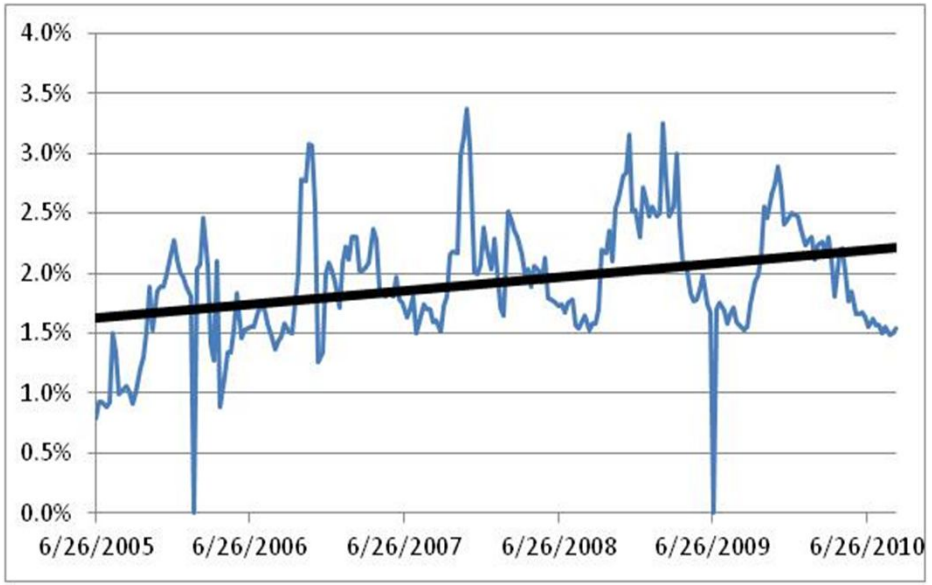
EPRI TPQ/DPQ III PQ Benchmarking Project

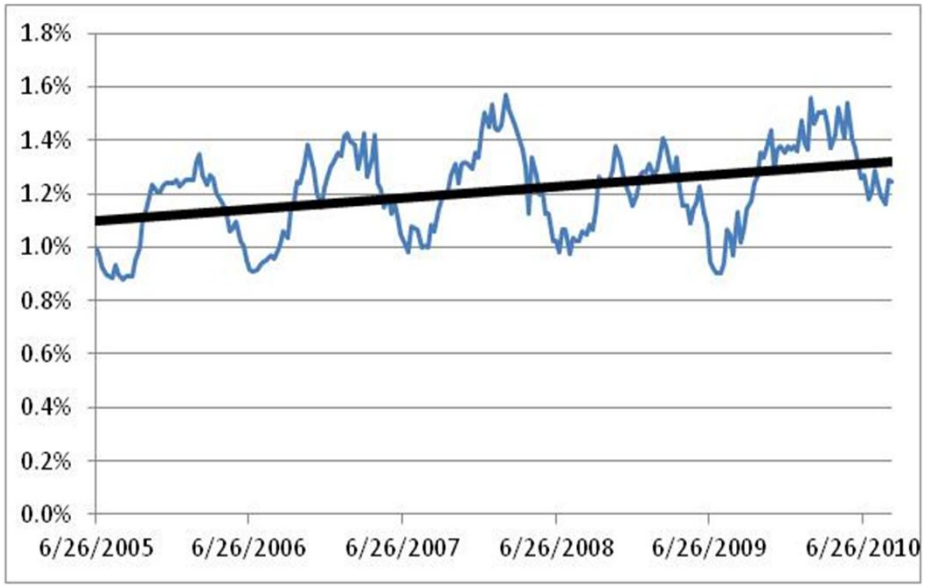
- Updated PQ Benchmarks
  - Voltage Sags
- New PQ Benchmarks
  - Harmonics
  - Transmission PQ
- Stratification of data
  - Feeder type and voltage
  - Region
  - Load served
- Trending of PQ performance
- Allow for a meta-analysis of the data from prior power quality studies (National and International)
- Allow the ability to determine what level of PQ performance is “normal” for a variety of circuits and applications

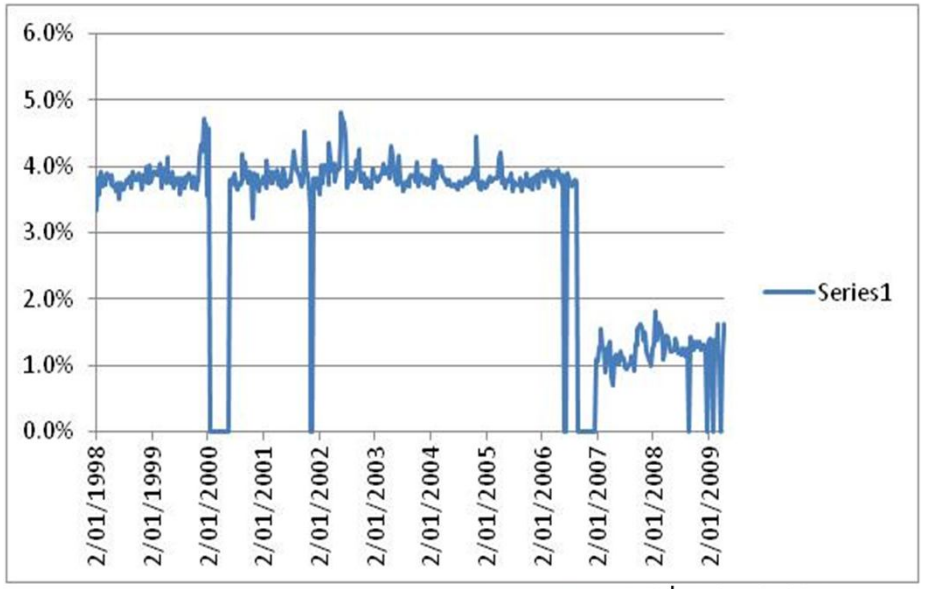


Difficulty in Combining Statistical Trends





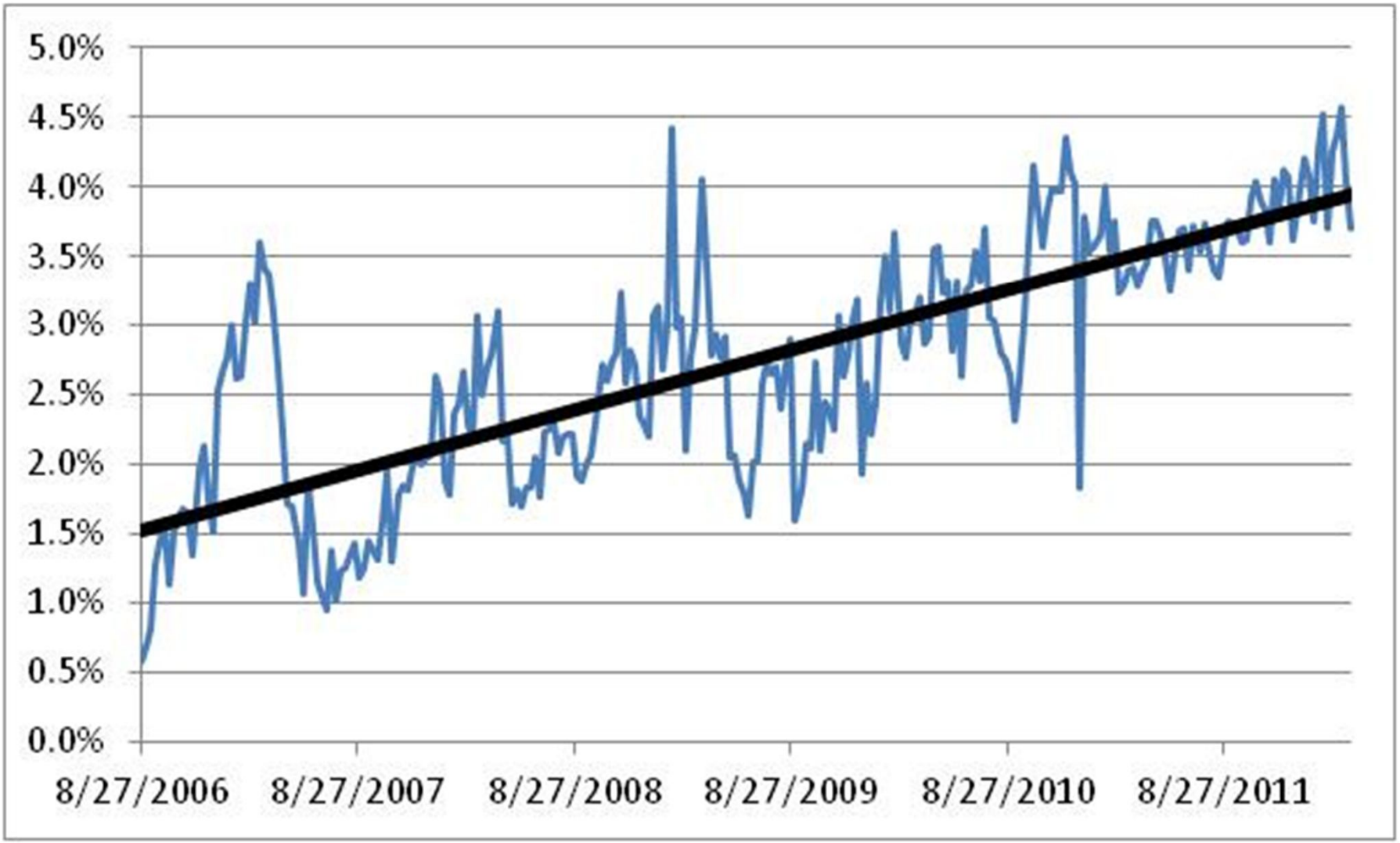




New - Results of July-September 2012 Analysis

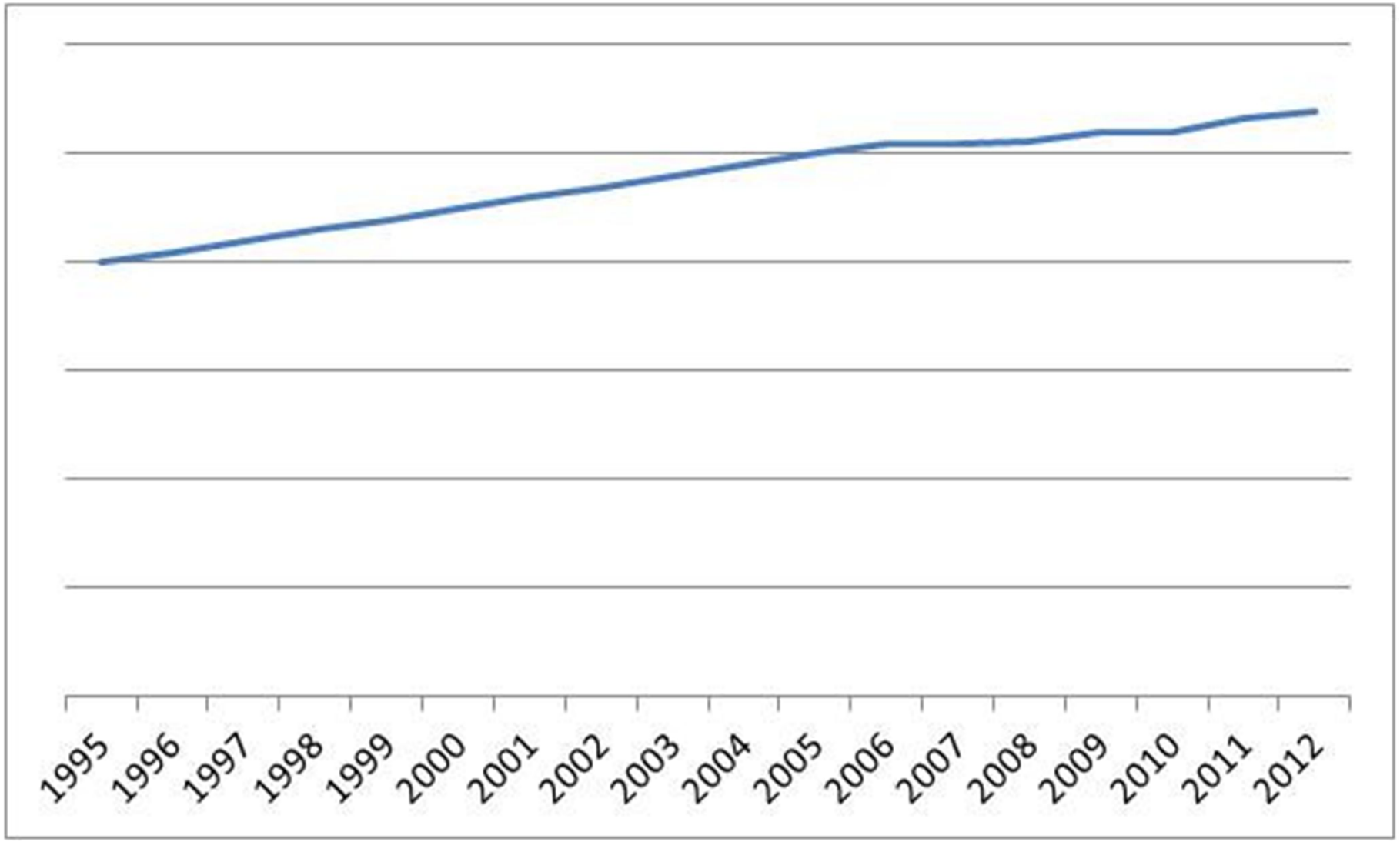
- 1000 Circuits
- 60 Randomly Selected for Detailed Trend Analysis
- 60% of all circuits showed increase in harmonics over time
- The range of increase was 3% per year (i.e. 30% over 10 years) etc… Example (2% THD in 2005 2.6% THD in 2015)
- 40% of circuits have stayed relatively flat - none showed a decrease over time
- For the circuits where the monitor was at a customer PCC point of common coupling instead of at the substation a third of those PCC's showed THD levels close to or exceeding IEEE 519 (4% to 7% THD) Example…**Likely because the monitors were placed at suspected cutomers with hight harmonic injection**

Example of the PCC monitors



EPRI ELECTRIC POWER RESEARCH INSTITUTE

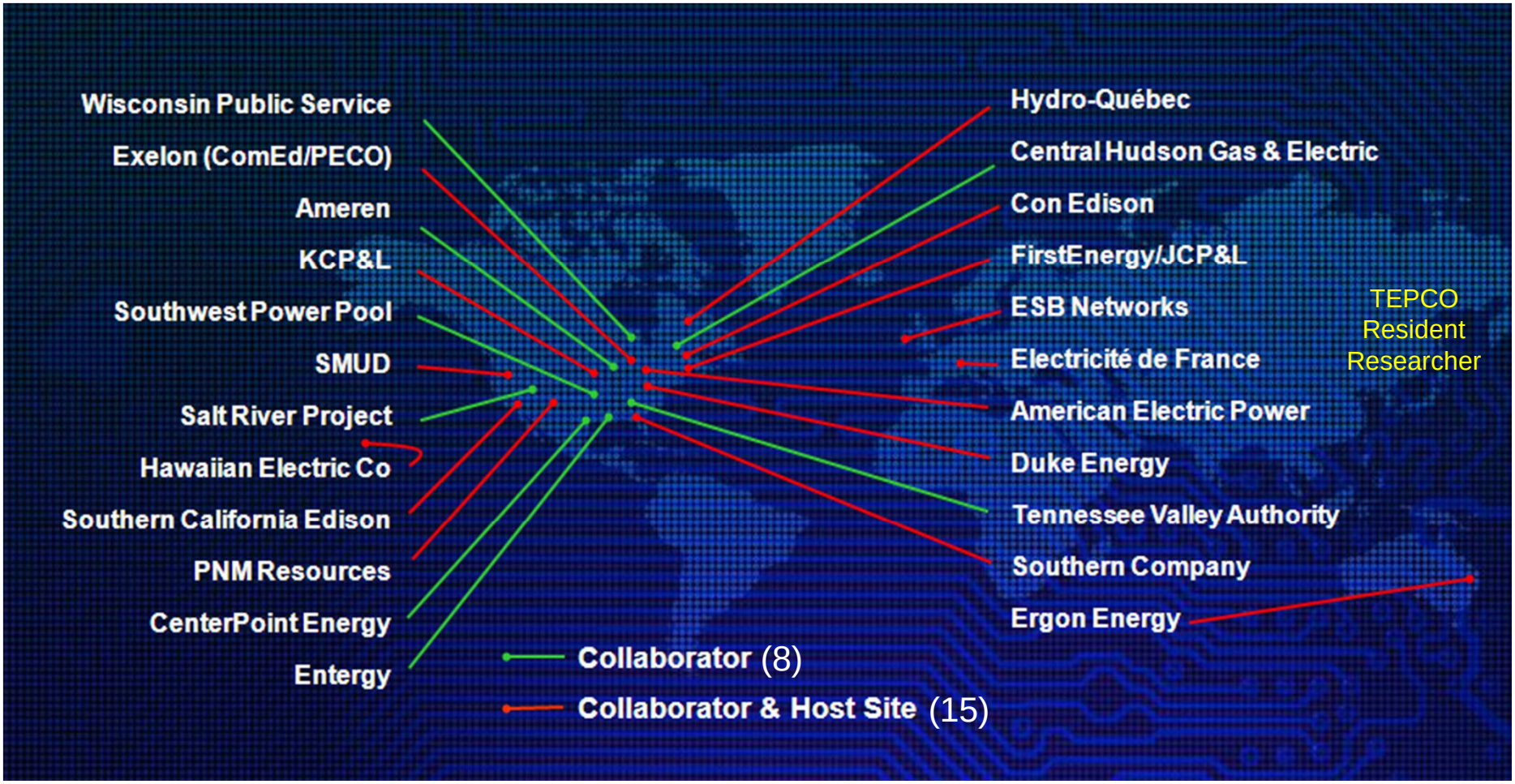
The General Trend looking at all the data sets….



EPRI ELECTRIC POWER RESEARCH INSTITUTE

EPRI Smart Grid Demonstration Projects

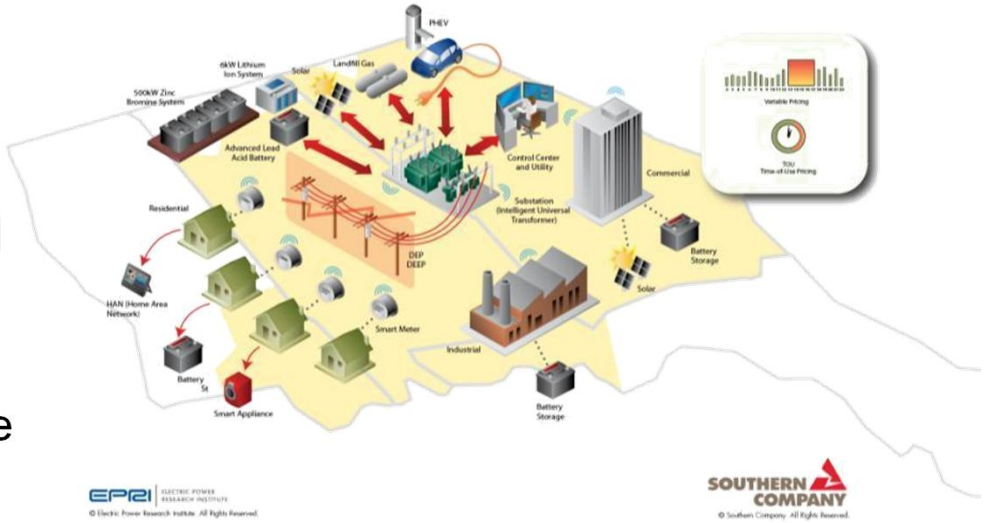
23 Utilities, 15 Large Scale Demonstrations



EPRI ELECTRIC POWER RESEARCH INSTITUTE

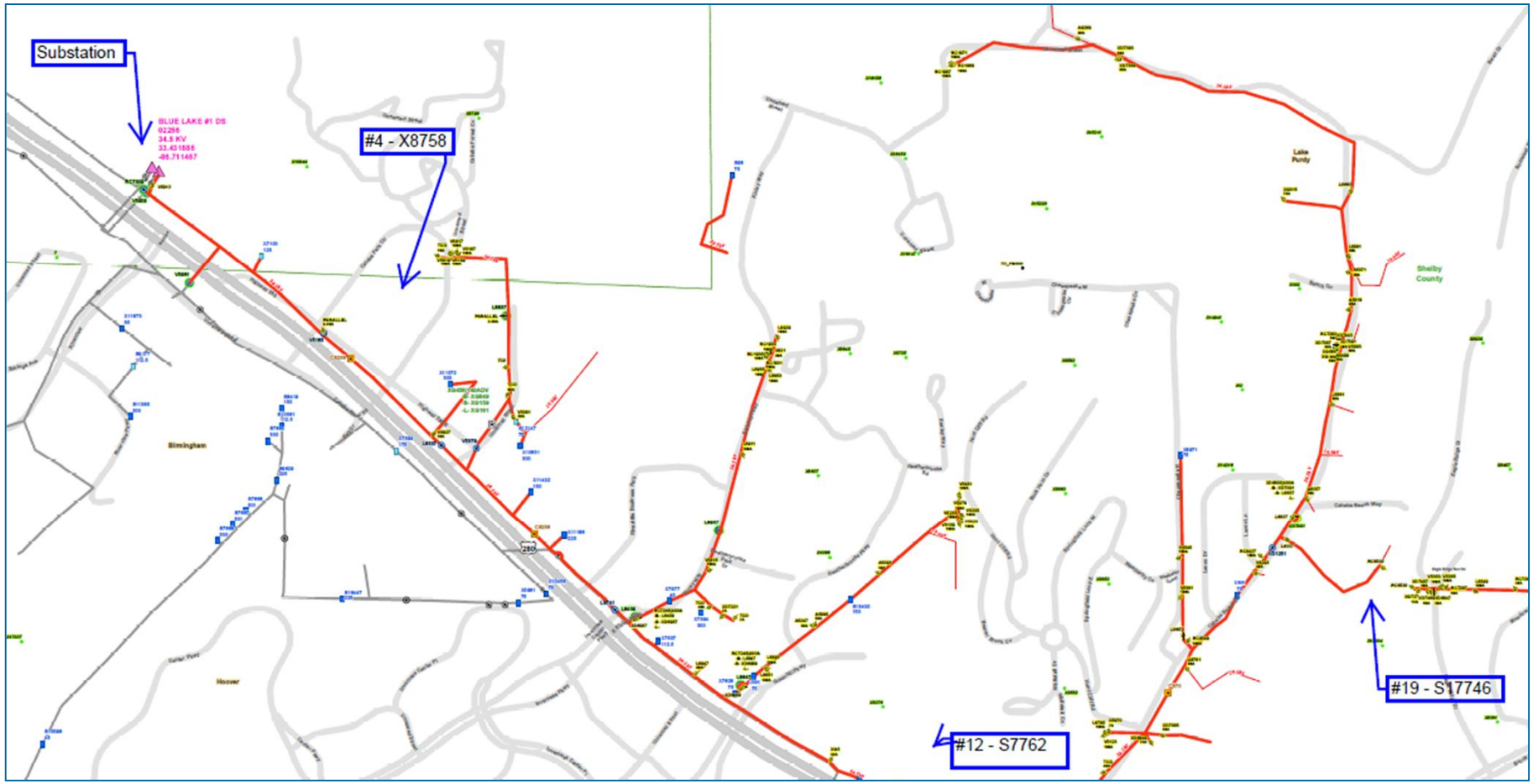
Southern Company – Smart Grid Demonstration

- PQ analysis to be conducted as part of their Distribution Energy Efficiency Program (DEEP)
  - Specifically around capacitor bank switching to maintain a near unity power factor during all periods of the year and to boost the voltage when CVR is implemented during peak load periods.
- DEEP (Distribution Energy Efficiency Program):
- GOAL - maximize the efficiency (minimize losses) of distribution circuits while providing a load management option
- Implement strategies from research projects:
- DROP – Distribution Regulation Option Program (APC)
- EPRI Green Circuits Research Project



EPRI ELECTRIC POWER RESEARCH INSTITUTE

Current Status of PQ impact assessment:
Refining Metering Locations, Analyzing Preliminary Data



EPRI ELECTRIC POWER RESEARCH INSTITUTE

Grid IQ Framework

Estimating Future PQ Impacts and DR Integration Issus

Research Needs

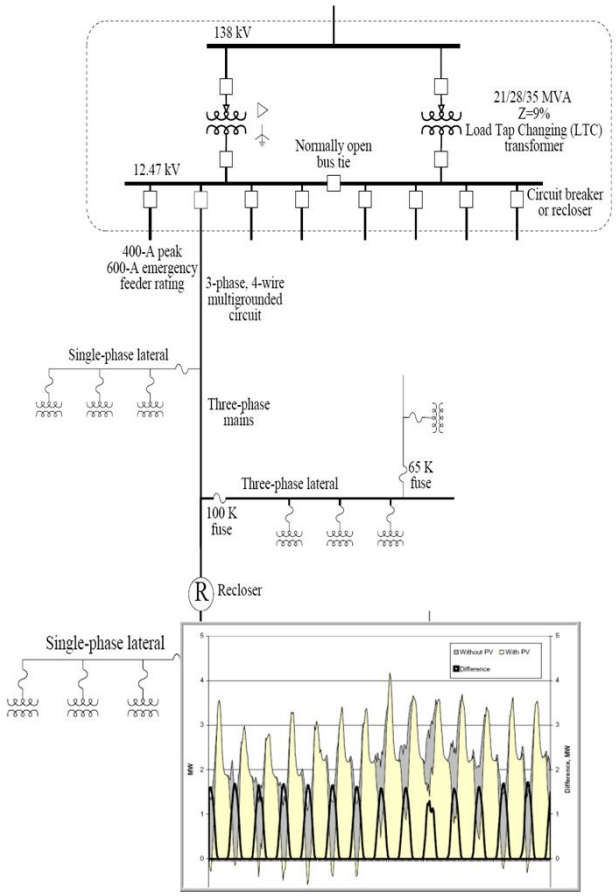
- **Future PQ Levels**: Need to estimate future PQ grid harmonics levels on transmission and distribution grids (Smart Grid)
- **Impact of New Loads**: Need to understand the impact of new loads on grid performance and for different grid configurations

Approach

- **Harmonics**: Develops analyses of future levels of harmonics based on application of load and grid models
- **Models and simulation**: Application of modeling tools to dozens of grid models

Current Research

- **Grid IQ Circuit Analysis** Using 2030 Load Mix Projections (Technical report)
- **Grid IQ Circuit Library**: US$1Million in circuit models from many utilities



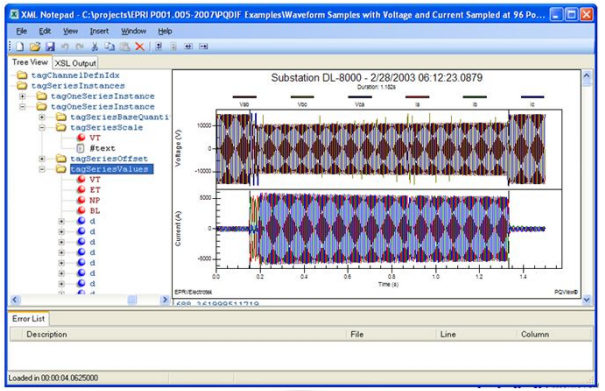
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Smart Meters

Long-term Strategy for Getting Good PQ Data

Research Needs

- **Proliferating Data Sources**: What data sources are reliable and which are not?
- **Integration of Data**: How can different data streams best be integrated and managed?
- **Smart Meters**: Are they a Reliable PQ data source?



Approach

- **Technology Assessment**: Evaluation of different data sources for quality of data
- **Standards**: Work closely with the IEEE Power Quality Subcommittee for storing PQDIF records in a database format

Current Research

- **Smart Meters**: Application and Performance Testing of Smart Revenue Meters (Technical Report)
  - Performance Testing
  - Product Specification Review
  - Enterprise success strategy

2012 1.004

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Questions?