Measurement Practices for Reliability and Power Quality

Transmission Reliability Peer Review
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Objective: A Reliability and Power Quality Measurement "Toolkit"

- **Distribution reliability metrics**
- **Power Quality**
- **Value of reliability**
- **Market role**
- **Lists of practices**
  - **Reliability**
  - **Power Quality**
  - **Active Organizations**

Stakeholders, Accomplishments,

- **Stakeholders: RUS, APPA, NRRI, NRECA, NYPSC, FERC**
- **Accomplishments: A draft report has been prepared and circulated for comment.**
- **There is significant interest now in reliability and measurements.**
- **The report has been reviewed by regulators, and requests were made to expand it.**
- **New sections on gaming and possible market roles in reliability.**

Significance, Deliverables

- **Significance: Reliability is becoming a regulatory issue – who controls it? how should it be enforced?**
- **FERC is developing a reliability division.**
- **Deliverables: A report on reliability measurements for regulators, utilities and customers.**

What Do We Discuss?

- **Reliability - Definition**
- **Power Quality - Definition**
- **LOLP Discussion**
- **IEC Standards Description and Discussion**
- **Pitfalls in Calculating Metrics Uniformly (Gaming)**
- **Use of Reliability Metrics and Valuing Reliability**
- **Standardizing Reliability Metrics**
- **Discussion of Electricity Market Issues, What Could Work with and Without a Market, Which Strategies Lend themselves to Performance Based Ratemaking**

What's In the Toolkit?
(Provided in the Appendices)

- **11 Sources for Terms and Definitions of Reliability**
- **7 Power Quality Standards, Guidelines and Measurement**
- **12 Activities and Organizations Developing and Sharing Information on Reliability and Power Quality**
- **Summary Table - Power Quality Standards Development Activities (Topic, Standard, ID, Subject)**
- **Discussion of the Quality - Reliability - Availability (QRA) Approach**
- **Discussion of the SEMI, CBEMA and ITIC curves**

Reliability

- **Covers total electric interruptions – loss of power.**
- **Indices typically consider variables such as:**
  - **The number of customers**
  - **The connected load**
  - **The duration interruption measured in seconds, minutes, hours or days**
  - **The number of hours of service demand**
  - **The kVA interrupted**

Some Sample Reliability Indices Are:
(Appendix A discusses the commonly used standards for reliability)

- **SAIFI System Average Interruption Frequency**
- **SAIDI System Average Interruption Duration Index**
- **CAIDI Customer Average Interruption Duration Index**
- **The indices are difficult to compare objectively, they also don't cover troubling sags and dips.**

Power Quality

(Appendix B discusses the commonly used standards for power quality)

Today's sensitive electronic loads are susceptible to:

- **Sags, swells, impulses, momentary interruptions.**
- **Also there are safety issues, grounding, elevated voltages**
- **And harmonics: THD, K Factor, Crest Factor,**
- **And steady state variations: flicker, noise, unbalance**
- **This is a rapidly growing and changing field.**

Loss of Load Probability (LOLP)

- **A historical metric, it is the sum of probabilities of all events when load is not fully supplied.**
- **It was used as a guide for building generation capacity, it is only an indicator.**
- **It is an expected value based on the adequacy of generation.**
- **It does not model the reliability of the transmission and distribution system.**
- **It can be calculated for on peak hours, or for each hour.**
- **It does not specify the magnitude or duration of the outage.**

International Electrotechnical Commission (IEC)

- **International standards developed by consensus with international working groups.**
- **They also develop Industry Technical Agreements (ITAs)**
- **Their standards are often different from, and incompatible with U.S. standards (IEEE, ANSI, NFPA, etc.)**
- **The report provides a list of 15 IEC standards for power quality, and corresponding U.S. standards where they exist.**

Pitfalls in Calculation of Reliability Indices

Significant Disparities in Calculation Method Exist, for example:

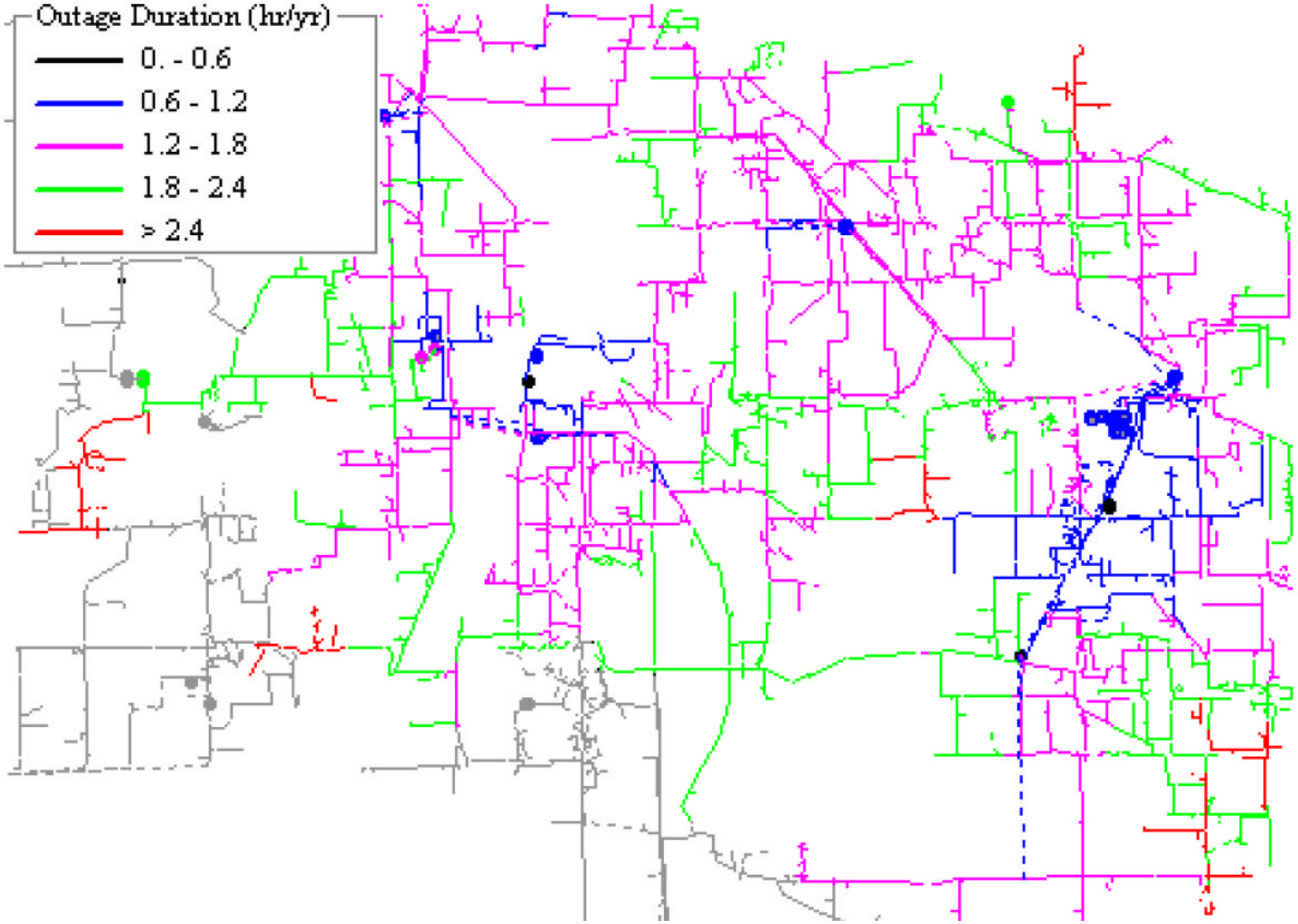
- **Are interruptions analyzed down to the substation, recloser, fuse or meter?**
- **SAIDI can double if you go all the way to the meter.**
- **MAIFI is the momentary av. int. index; if MAIFI data is included in SAIDI, SAIDI can triple.**
- **Major events are excluded, but major events can be defined differently.**
- **Indices compared between utilities can be quite misleading.**

Valuing Reliability

- **Some utilities have developed performance standards with financial penalties based on indices.**
- **For example, to avoid financial penalties, Pacific Power will :**
  - **Improve SAIDI and SAIFI by 10% by 2005**
  - **Improve the 5 worst distribution circuits by 20% in each state (repeating for 5 years)**
  - **The indices are calculated using outage data automatically acquired by a computer based system.**

Commonwealth Edison

- **After a series of major distribution outages in ’99, Com Ed did a major investigation and study.**
- **A predictive reliability model was developed for over 3,300 feeders.**
- **Different upgrade schemes can be compared from cost benefit perspective.**
- **The most cost effective approaches are not always obvious.**


Outage Duration (hr/yr)
0. - 0.6
0.6 - 1.2
1.2 - 1.8
1.8 - 2.4
> 2.4

Standardizing Reliability Metrics

- **Reliability depends on a number of factors such as circuit layout, climate, inspection and maintenance, etc.**
- **A uniform computer based system programmed and managed identically between utilities would be required to obtain standardized metrics.**
- **This managed system would acquire data and calculate indices uniformly.**
- **Some utilities will inherently have better indices than others due to climate and geography.**
- **It will be a "sea change" for utilities to accept the imposition of a standardized system**
- **A standardized system may be ordered by FERC and implemented by NERC.**

Market Role

- **Performance based rates can provide a financial incentive for the distribution company to deliver the desired reliability level.**
- **Payments would ideally be set above the projected cost of improvements and below the value of the quality as desired by consumers. There is no point in increasing performance if cost exceeds value.**
- **Customers would much rather receive quality service than receive payment for poor quality.**

Key Principles in Incentive Design

- **Clearly specify the metrics and incentives in advance.**
- **Make the metrics and incentives as simple as possible for both distributors and customers without distorting the incentives.**
- **Ensure that performance measurement is verifiable.**
- **Address worst-case performance as well as average performance.**
- **Provide penalties for under-performance as well as incentives for exceeding targets.**
- **Limit the financial risk, especially when first implementing the system, but make the incentive large enough to provide real motivation. Incentives should be greater than the cost to the distributor to achieve the incremental improvement, but less than the value to customers.**

Major Sources for Terms and Definitions of Reliability (Appendix A)

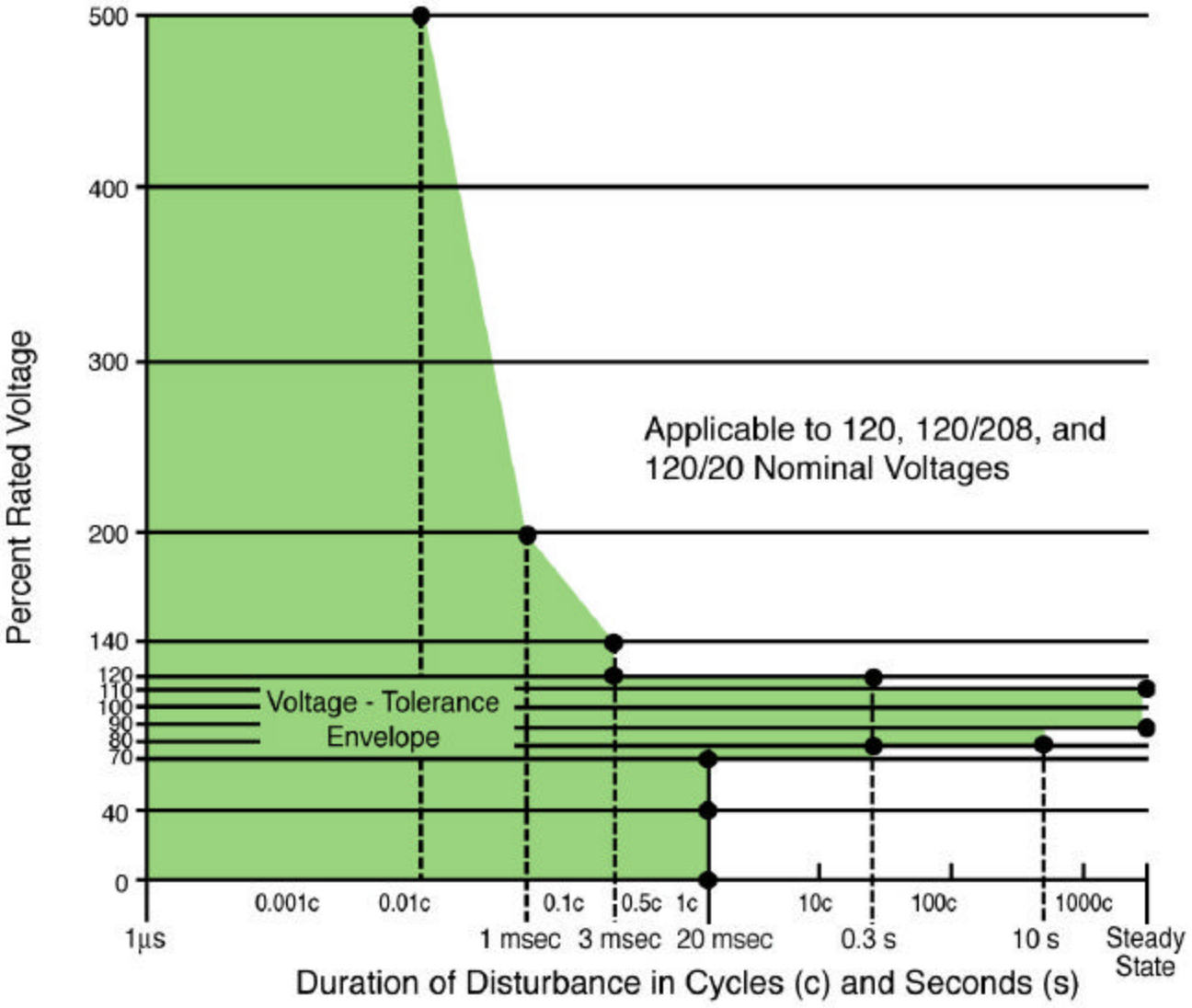
- **IEEE Std. 1366-1998:** ***Trial Use Guide for Electric Power Distribution Reliability Indices***
- **IEEE Std. 762:** ***Definitions For Use in Reporting Electric Generating Unit Reliability, Availability and Productivity***
- **IEEE Std. 859-1987*: Standard Terms for Reporting and Analyzing Outage Occurrences and Outage States of Electrical Transmission Facilities***
- **IEEE Std. 493-1997*: Recommended Practice for Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)***

Power Quality Standards and Guides
(Appendix B)

- **IEEE Std. 519-1992:** ***IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems***
- **IEEE Std. 1159-1995:** ***IEEE Recommended Practice for Monitoring Electric Power Quality***
- **IEEE Std. 1100-1999:** ***Recommended Practice for Powering and Grounding Electronic Equipment***
- **IEEE 1250-1995 IEEE:** ***Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances***
- **IEEE Std. 1346-1998:** ***IEEE Recommended Practice for Evaluating Electric Power System Compatibility with Electronic Process Equipment***

Other Topics in Reliability
(Appendices C through F)

- **Activities and Organizations Active in Reliability and Power Quality (12 are listed)**
- **EPRI – QRA**
- **Industry**
  - **SEMI**
  - **CBEMA**
  - **ITIC**



Conclusions

- Some utilities are already instituting performance based standards.
- There is ample opportunity to skew the numbers with the present methods.
- There are a multiplicity of standards, indices, measures and activities in this area.
- The market approach to ensuring reliability and power quality is workable and starting to show results in some parts of the nation.
- The report is needed to outline the basics on reliability for the regulator, utility and customer.
- Performance based ratemaking and national regulation of reliability are coming, a baseline report of the present state of reliability measurements is badly needed.