# Synchrophasor Technology and Blackout Prevention and Analysis Panel

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# Panelists

- Introduction – Vahid Madani & Damir Novosel
- US/Canada 2003 and Southern California/Mexico Blackouts – Bob Cummings & Alison Silverstein
- WECC Efforts to Improve Reliability – Steve Ashbaker, WECC
- Brazilian Blackouts – Renan Giovanini, ONS, Brazil
- Phasor Measurements for Blackout Prevention – Anjan Bose (DOE)
- IEEE PES Initiatives – Marianna Vaiman (V&R Energy)

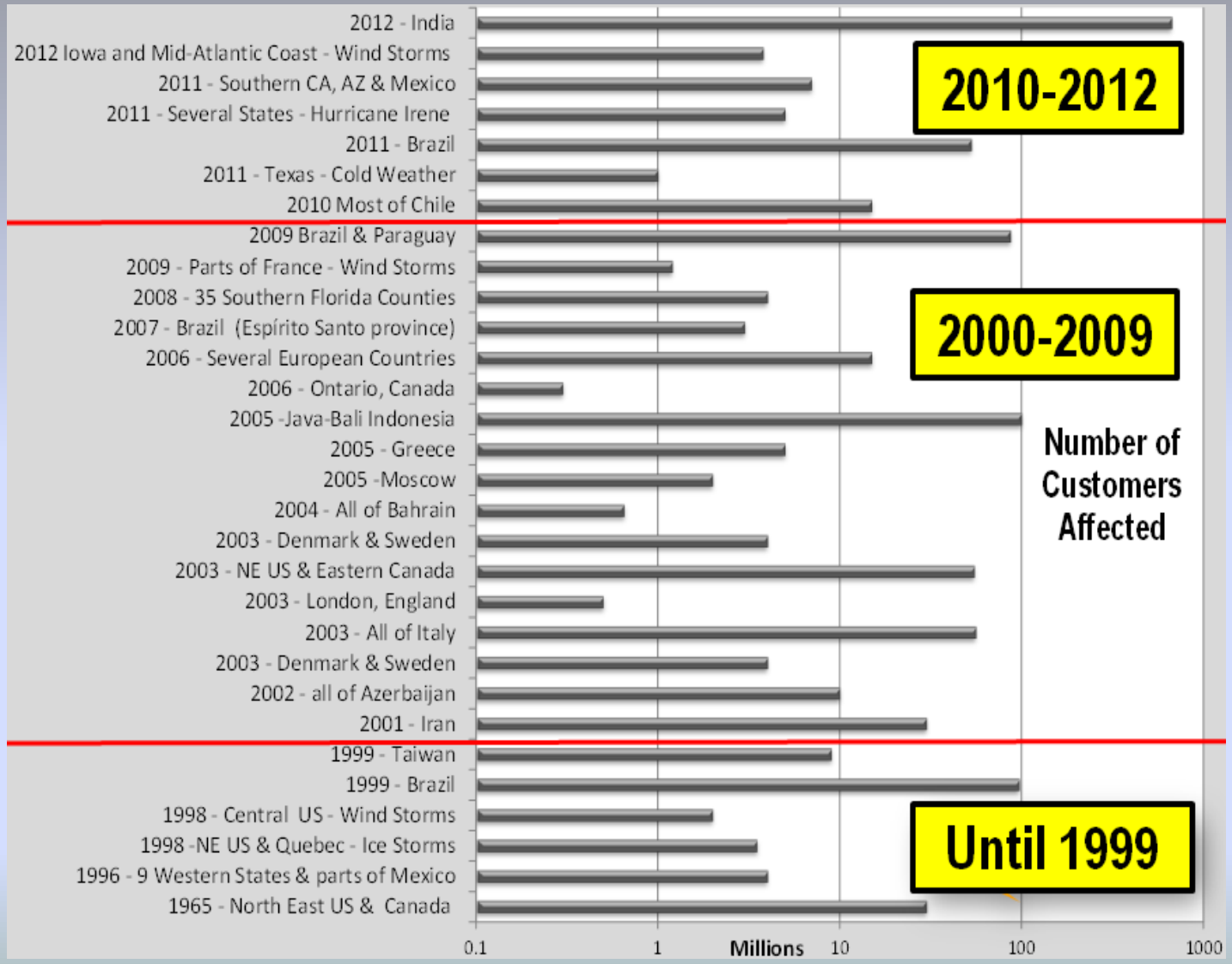
# Preventing Large Blackouts

*Multiple Contingencies with Complex Interactions*


- System operated outside the limits
- Usually no "single" cause
- Sequence of low probability events difficult to predict accurately
- Infinite number of operating contingencies, different from the expectations of system designers
- Operators cannot act fast enough for fast developing disturbances

# Significant Global Power Outages

## 1965-2012

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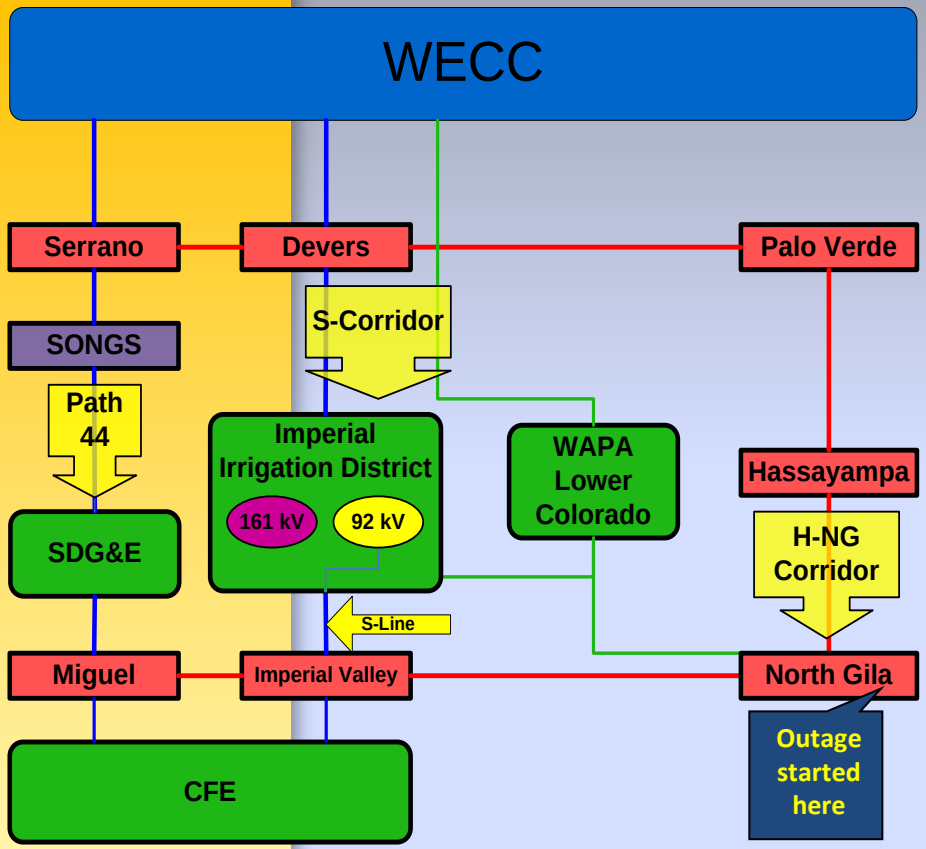
# San Diego Blackout – Sep. 2011

## Over 30 'major element' operations in 11 minutes




- Weaknesses in two broad areas
  - Operations planning
  - Real-time situational awareness
- Contributing factors
  - Not studying impact of sub 100 kV facilities parallel to EHV
  - Failure to recognize IROLs
  - Not studying/coordinating effects of protection systems and RASs during contingency scenarios
  - Not providing effective operator tools and instructions for reclosing lines with large phase angle differences

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*Source: Bob Cummings, NERC*

# Lessons Learned – FERC Report, Situational Awareness

## Angular Separation

- Ability to determine, in real time, the standing angles that would result following major transmission line outages
- Placing PMUs in locations such that standing angles can be seen directly by system operators in SCADA/EMS systems

## Real-Time External Visibility

- Lack of adequate awareness of external contingencies that could impact one's system

## Real-Time Tools

- E.g., Without having tools in place to determine the phase angle difference between the two terminals of a line after the line tripped, one should not / cannot commit to restore the line quickly.
- Need seasonal and next-day contingency analyses that address the angular differences across opened system elements
- Having, but not using the real-time tools to monitor system conditions
- Real-Time Contingency Analysis (RTCA) tools need to be functional and operating

# Recommendations

## After 2003 U.S./Canada Outage

*August 14, 2003 Outage: U.S.-Canada Power System Outage Task Force Report*

"A valuable lesson is the importance of having time-synchronized system data recorders. The Task Force's investigators labored over thousands of data items to determine the sequence of events, much like putting together small pieces of a very large puzzle. That process would have been significantly faster and easier if there had been wider use of synchronized data recording devices…"

Recommendation 12a – The reliability regions, coordinated through the NERC planning committee, shall within one year define regional criteria for application of synchronized recording devices in power plants and substations…

# Recommendations

## After 2006 European Outages

*November 4, 2006 Disturbance - UCTE Final Report*

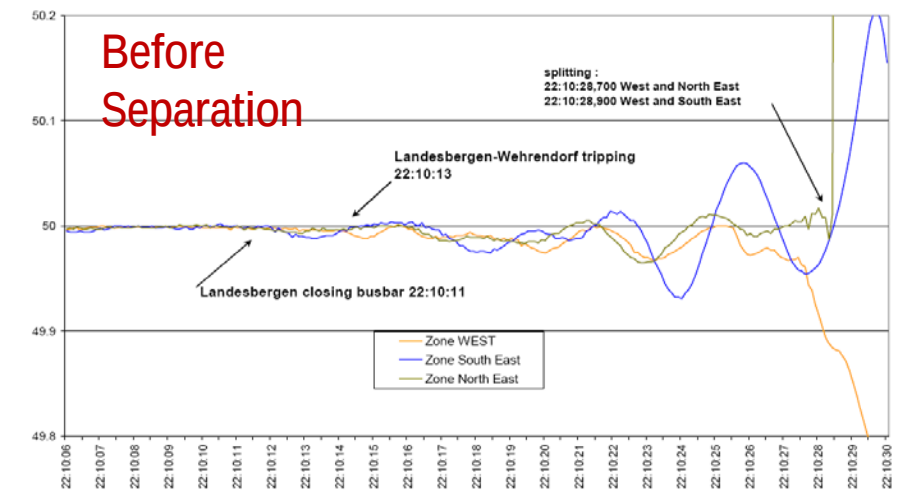
UCTE-wide Awareness System

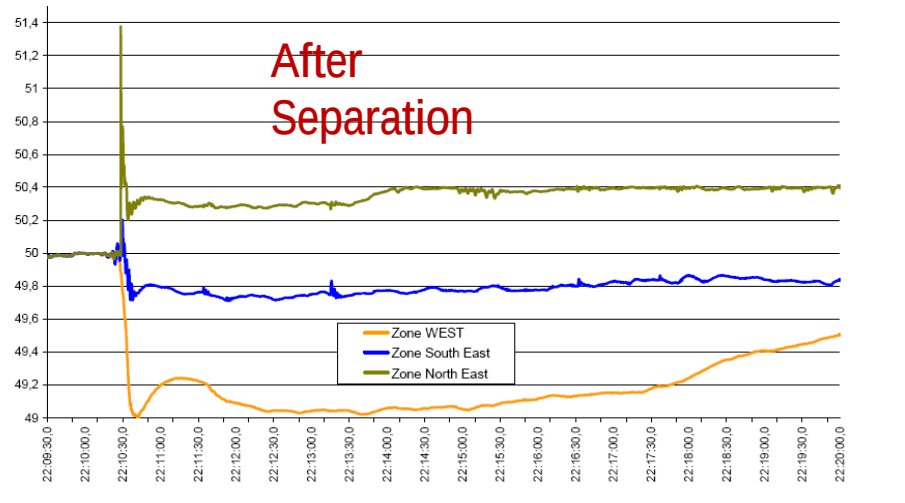
" …On November 4, this was true more than ever – the information about the split of the system into three areas was available to some operators with significant delay. This issue might be solved via a dedicated central server collecting the real-time data and making them available to all UCTE TSOs. In this way, each TSO will obtain within a few minutes essential information about disturbances beyond their own control area. "

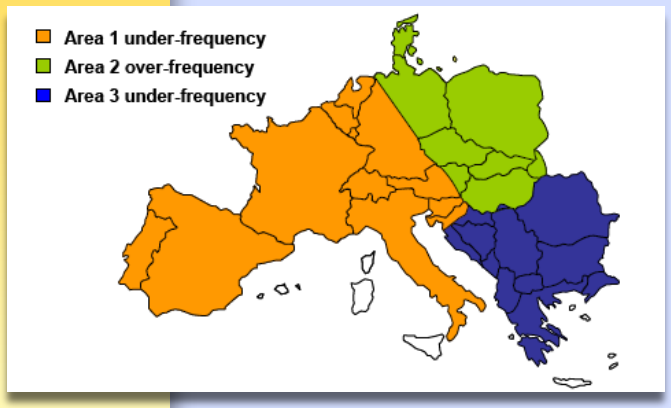
Recommendation 4 - UCTE has to set up an information platform allowing TSOs to observe in real time the actual state of the whole UCTE system in order to quickly react during large disturbances.

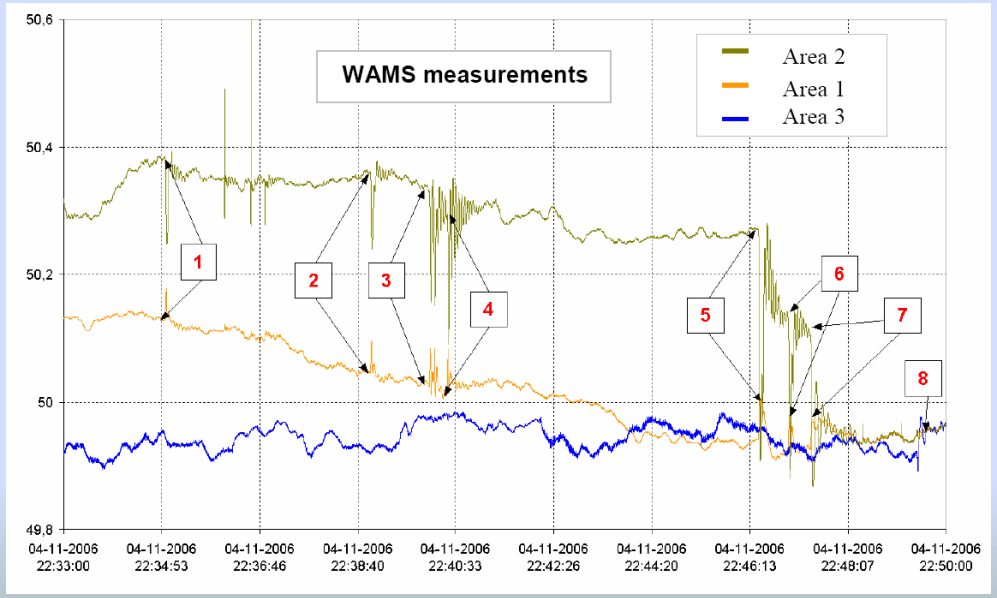
# November 2006 Europe

## Synchronized Data

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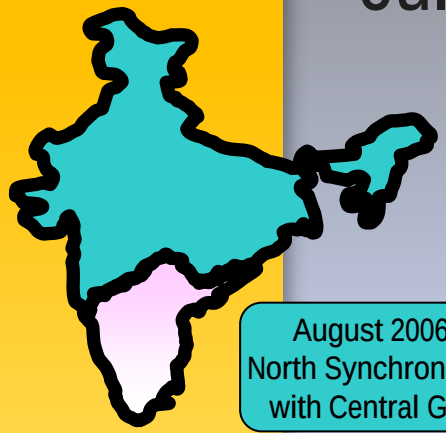
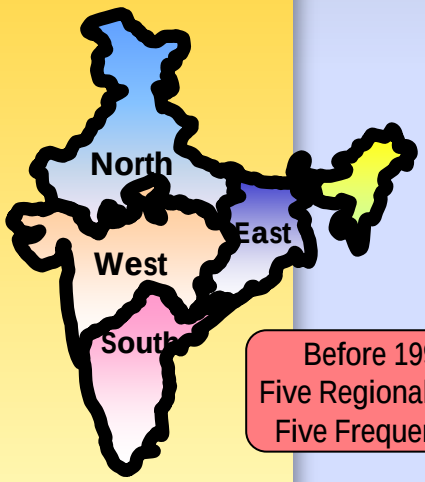
# India Blackout

## July 2012



August 2006:
North Synchronized
with Central Grid




Before 1991:
Five Regional Grids
Five Frequencies

- Weak Inter-regional Corridors due to multiple outages of transmission lines in the West-North interface
  - 400 kV Bina-Gwalior-Agra, the only main AC circuit between West-North interface prior to the disturbance
- High Loading on 400 kV Bina-Gwalior-Agra link due to unscheduled interchange
  - Inadequate response to reduce loading
- Loss of 400 kV Bina-Gwalior link on Zone-3 distance relay caused the North to separate from the West

*Source:* Report from the Enquiry Committee on Grid Disturbances in Northern Region, India, September 2012

# India Blackout

## Key Findings

- Better visualization and planning of the corrective actions
- Deployment of Wide Area Monitoring, Protection and Control Systems
- Better regulation of interchanges
- Better coordinated planning of outages of state and regional networks, specifically under depleted condition of the inter-regional power transfer corridors.
- Mandatory activation of primary frequency response of Governors
- Adequate reactive power compensation, specifically dynamic
- Under-frequency and df/dt-based load shedding
- Avoid  miss-operation of protective relays

*Source:  Report from the Enquiry Committee on Grid Disturbances in Northern Region, India, September 2012*

# Benchmark North America Projects

## Smart Grid Investment Grants: 3-Year Deployment

### Synchrophasor Applications

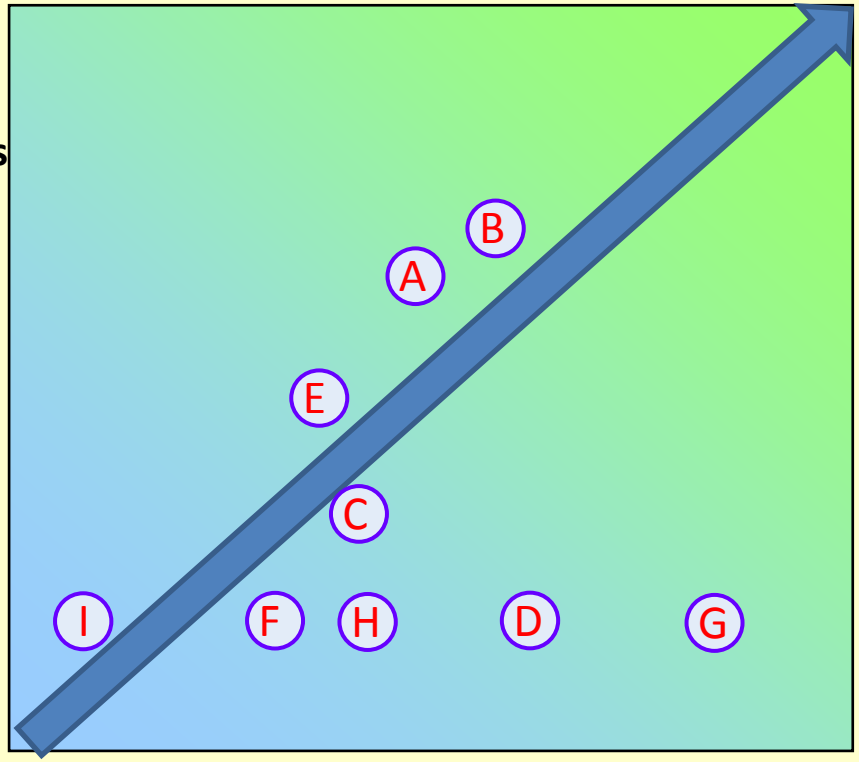
*Aggressive*

**Big bang – all real-time closed loop control, protection, operation & other applications**

**Control room functions; some real-time applications**

**Data visualization and operation analysis in control room**

**Monitoring; visualization & operation analysis outside of control room**




*Conservative*

Number of PMUs

X ***On-going US Synchrophasor Projects***

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# Preventing Blackouts

**New York City on October 31, 2012**
Photographer Iwan Baan
Image published in New York Magazine

- Widespread electric outages are a symptom of strategies for grid management
- Analysis of recent disturbances reveals common threads
  - Learn from the past and proven methods to mitigate
  - Blackout propagation should be arrested
  - Restoration time could be reduced

- Use of Synchronized measurements for Improved Situational Awareness and Control
- Not possible to avoid multiple contingency initiated blackouts

***HOWEVER…***

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# Preventing Blackouts

The *Probability,*

*Size* and

*Impact* of

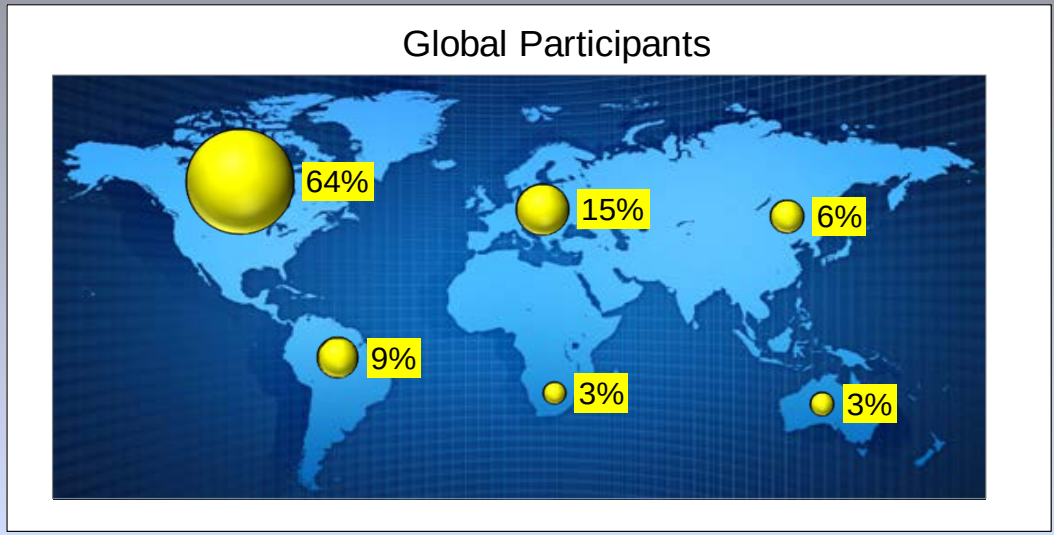
*Wide Area Blackouts*

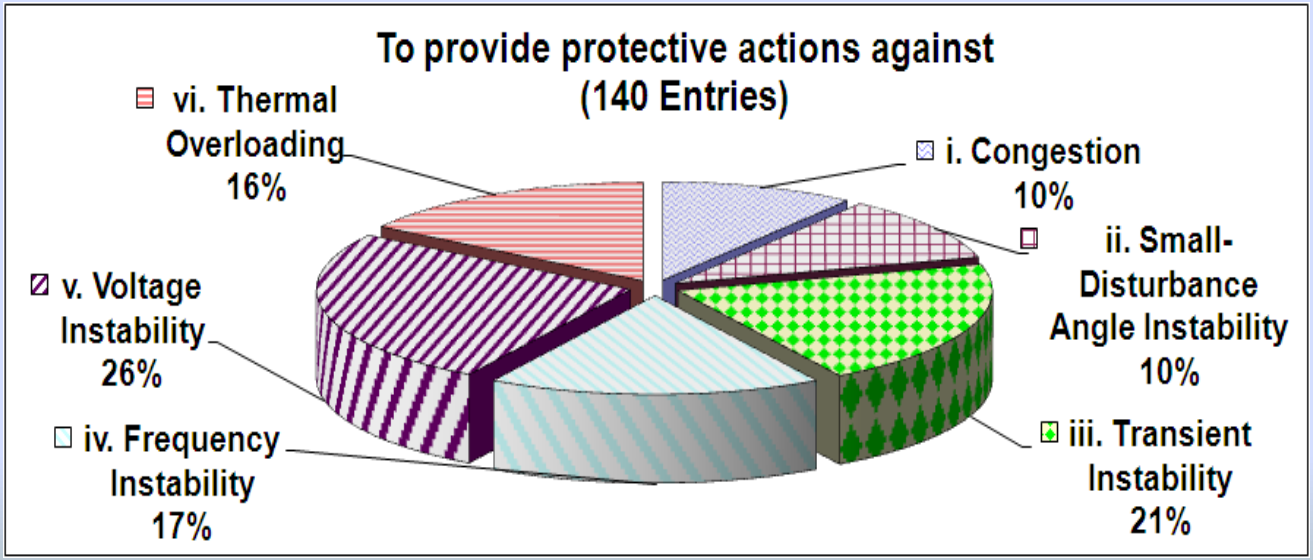
can be

*REDUCED* …… !!

# Experiences with SIPS

**IEEE PSRC Report - 2009**

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