Advanced Transmission Technologies and Superconductivity

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and
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What is It?

- More than 100 years old
- Constantly evolving and growing
- Critical to the economy and each of us.
- The major technological achievement of the 20th century
- The largest machine in the world!

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"Commodity" Aspects of Electric Power

- Electricity is not a simple commodity
- Complex multi-attribute service
- Treating electricity as a simple commodity is a gross approximation
- Electric power has BOTH private and public good aspects

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Public "Goods" Attributes

- Voltage
- Frequency
- Reliability
- Power Quality
- Losses (Real & Reactive)

Markets Do Not Efficiently Provide Public Goods

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"We are a major superpower with a third-world electrical grid."

New Mexico Gov. Bill Richardson

August 2005

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"A smaller transmission margin for reliability makes the preservation of system reliability a harder job than it used to be. The system is being operated closer to the edge of reliability than it was just a few years ago."

U.S –Canada Power System Outage Task Force
Causes of the August 14 2003 Blackout in the United States and Canada

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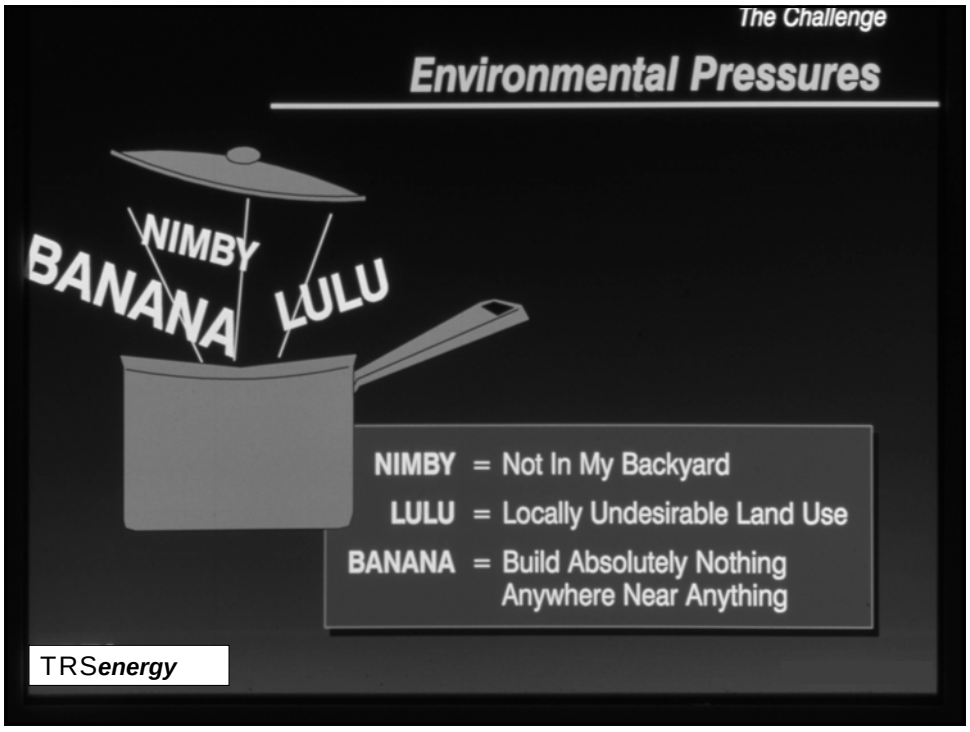

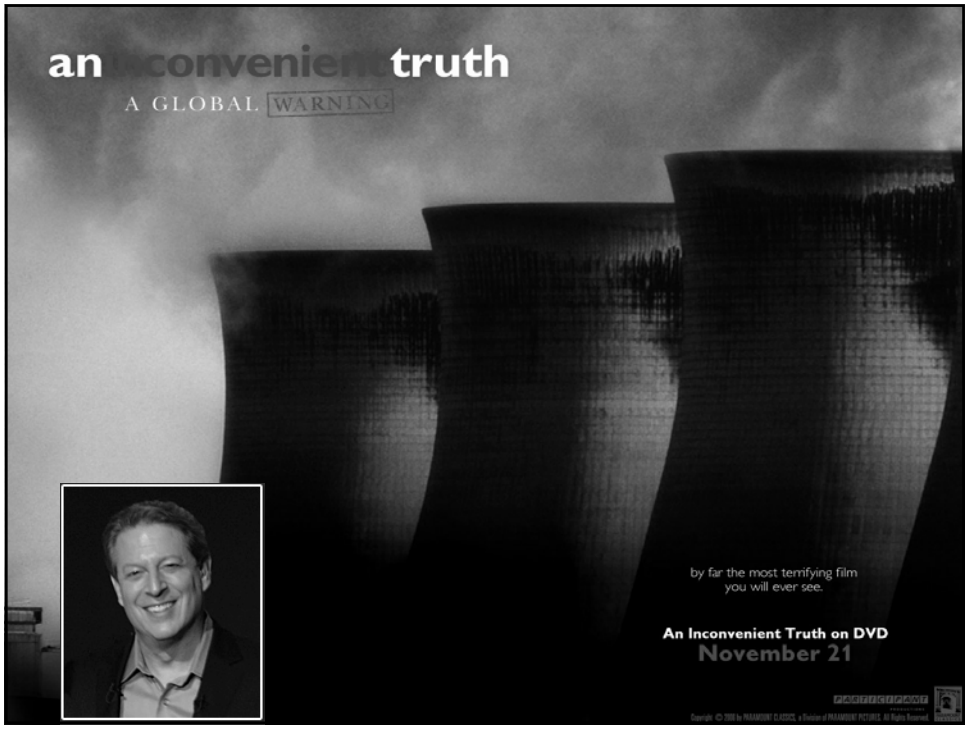
an inconvenient truth
A GLOBAL WARNING
by far the most terrifying film you will ever see.
An Inconvenient Truth on DVD
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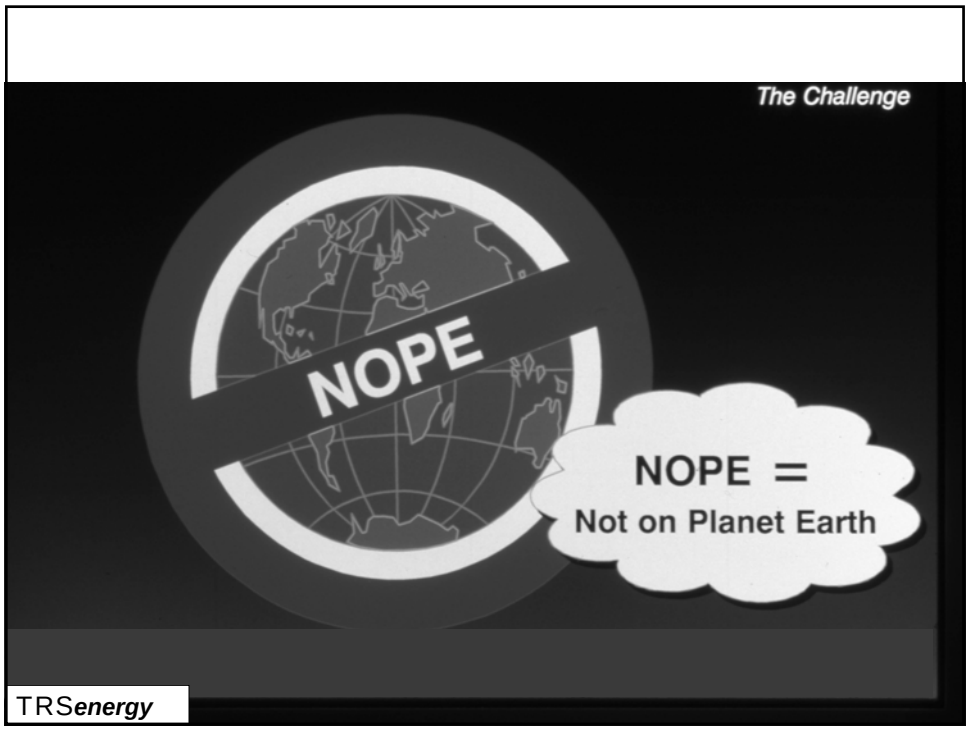
The Challenge
NOPE
NOPE =
Not on Planet Earth
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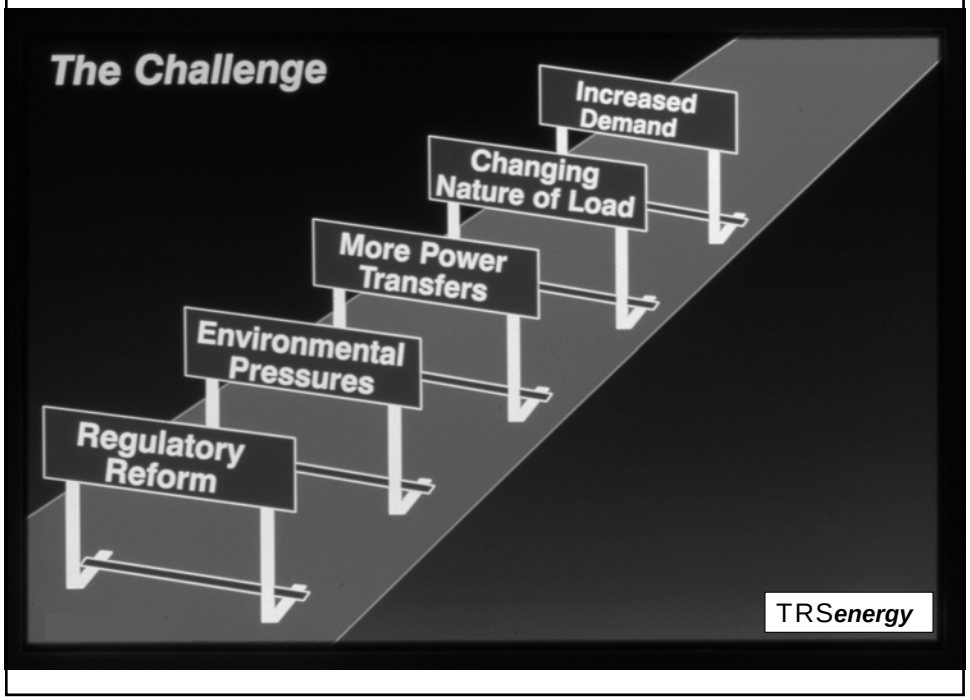

Reliability Depends on

- Engineering design, quality construction, proper maintained and operation - Reliability is an engineered outcome,
- Unused and Underutilized Generation!
- Unused and Underutilized Transmission!

Will Competitive "Free Markets" Ever Build What is Seldom Used?

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Reliability Depends on

For the power system to be reliable, the participants must cooperate, for markets to be competitive, the firms must compete."

Charlie Rudasill, VEPCO, retired

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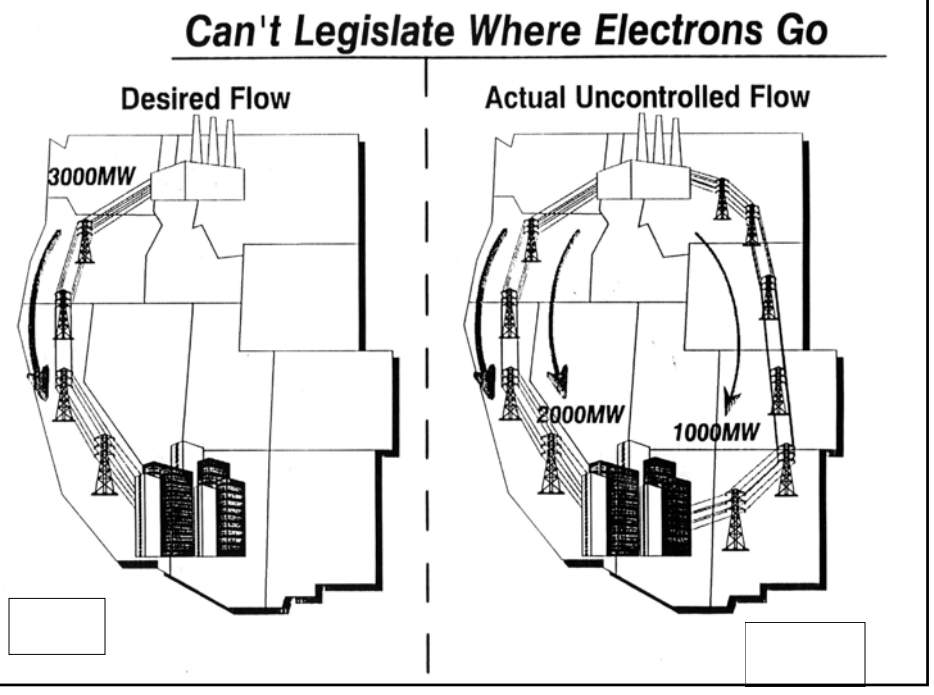

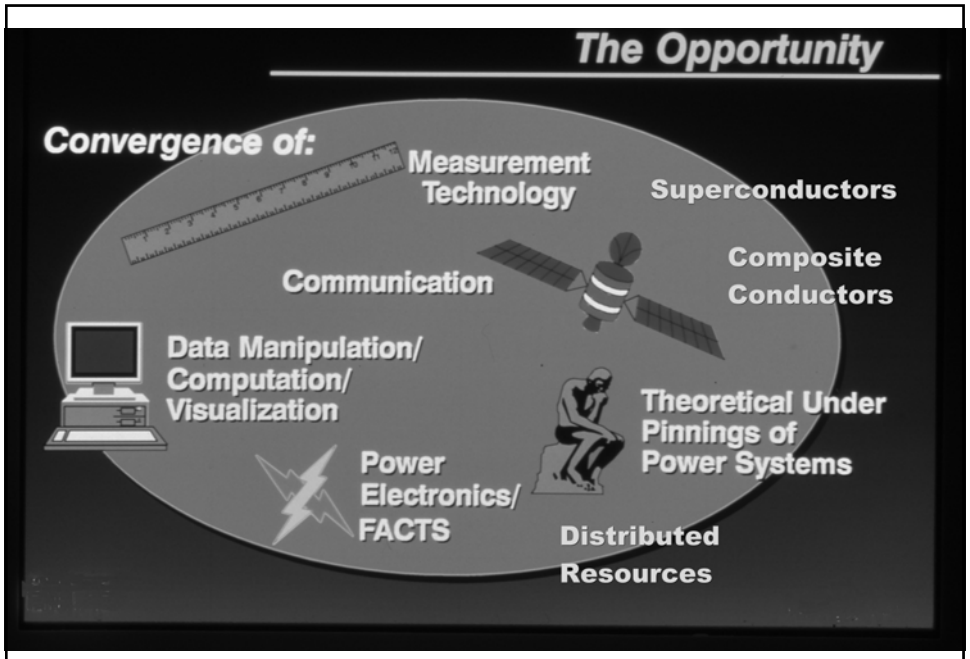

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Local and Global

- Improved local capabilities
  - Use of Dynamic Ratings
  - Increased capacity in ROW with new conductors and line designs
  - Control of AC line loadings (FACTS) Power electronics to control flow and voltage
- Improved global capabilities
  - Rapid, reliable, accurate acquisition and transmission of critical data to system managers
  - Increased understanding of system in operation
  - Reduction in outages and faster recovery from outages

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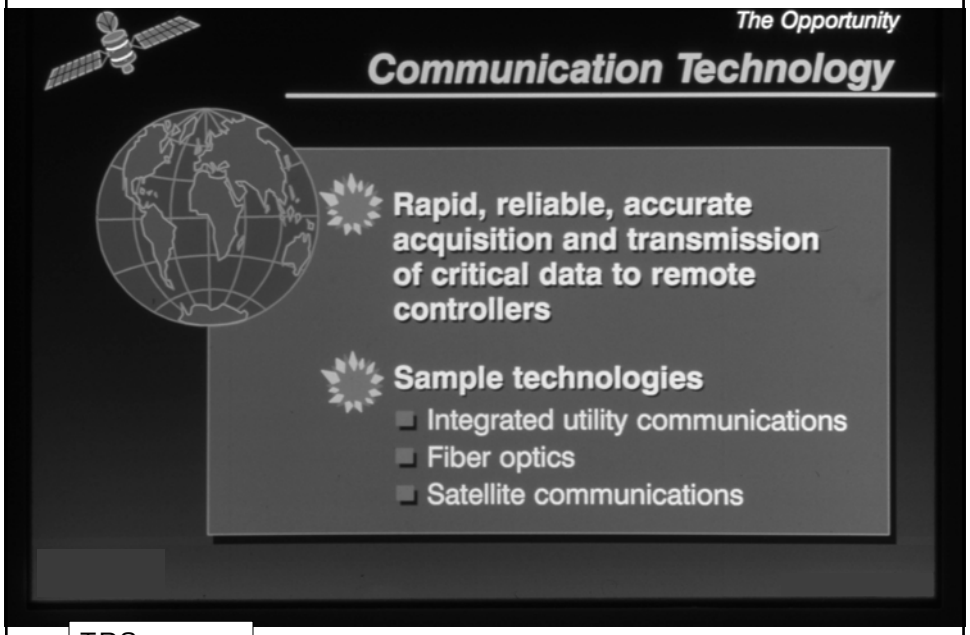

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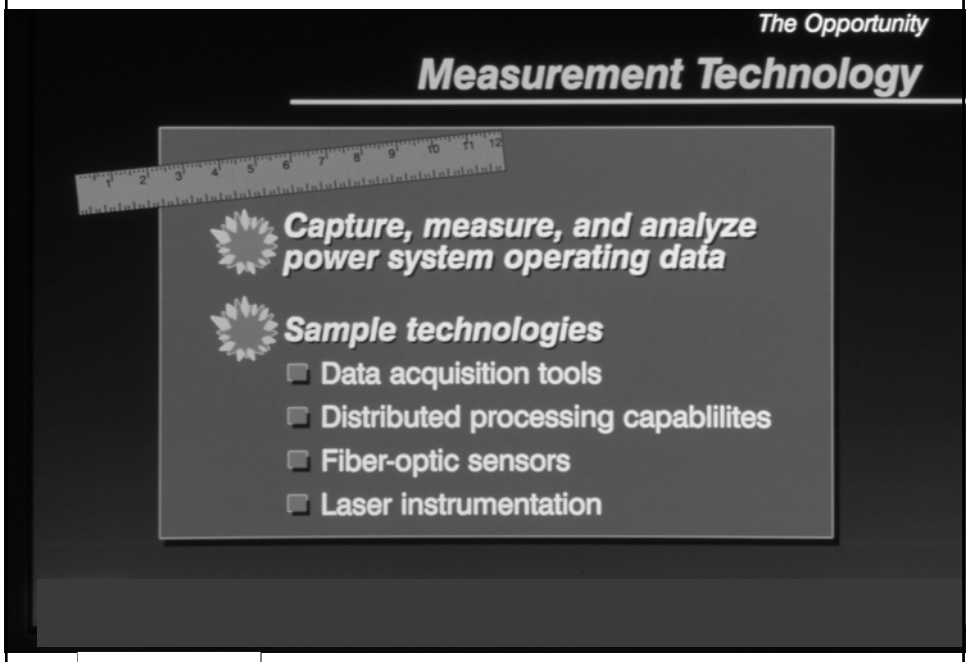

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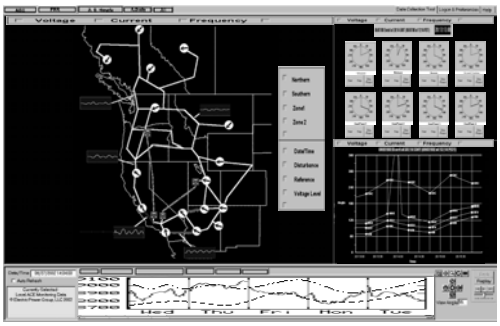
Synchronized Phasor Measurement

Real time Monitoring and Alarming of regional angle differences against predefined thresholds

Computer Screen



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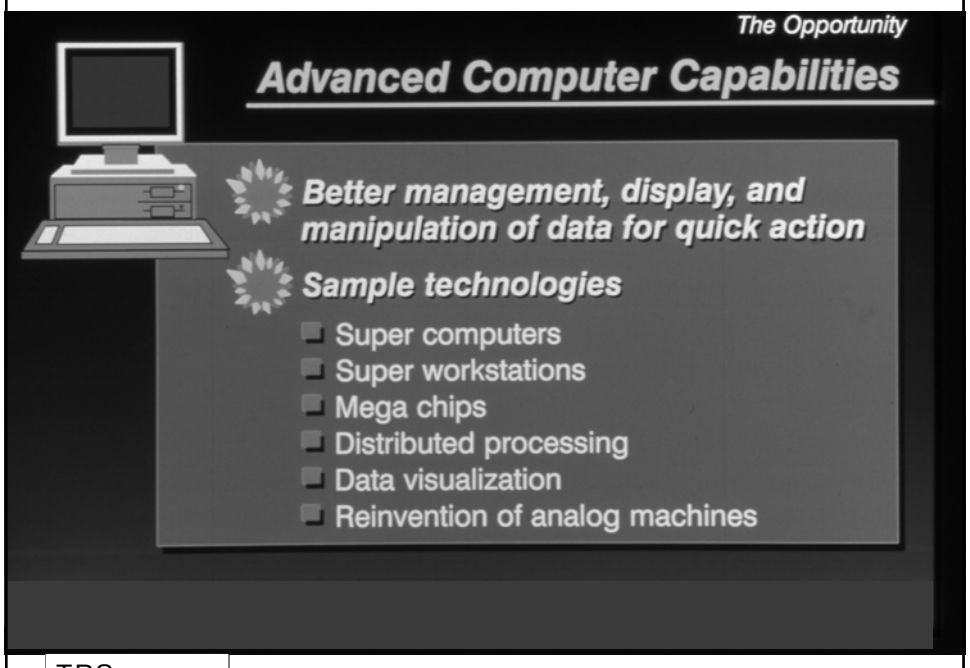

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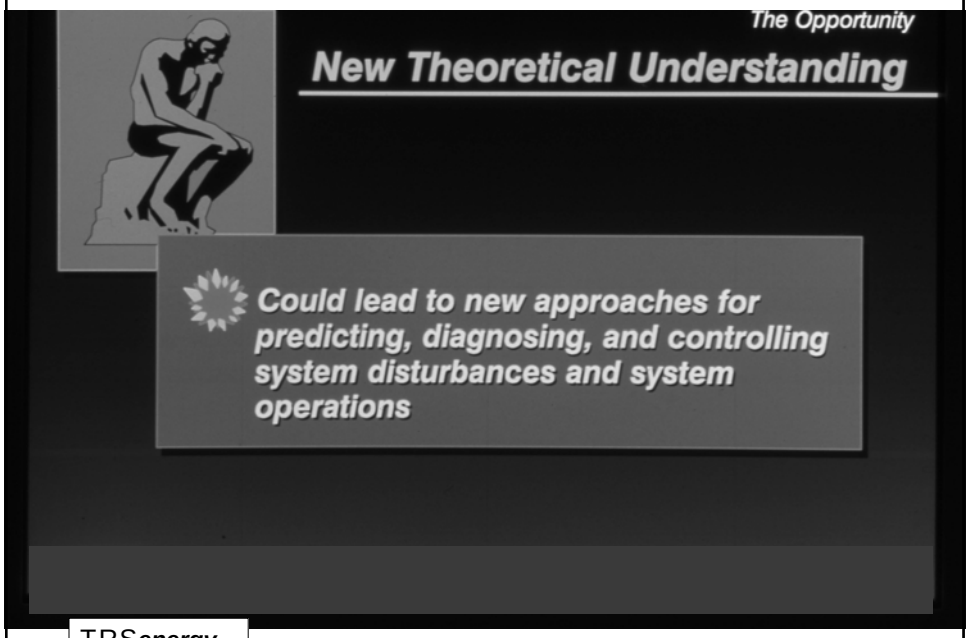

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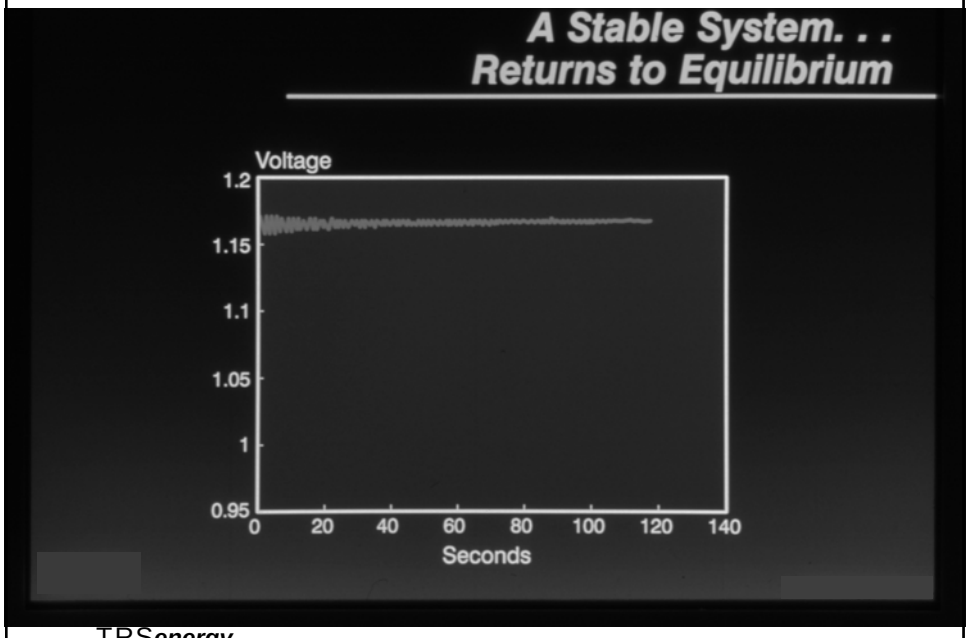

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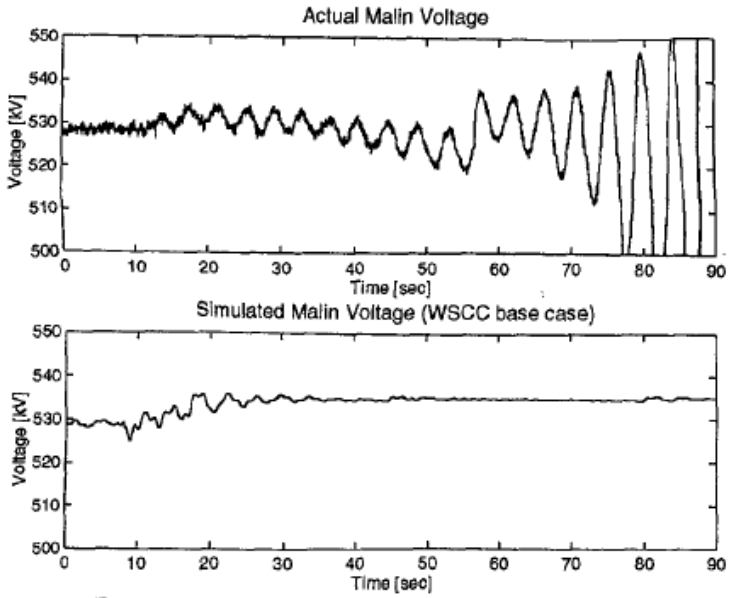
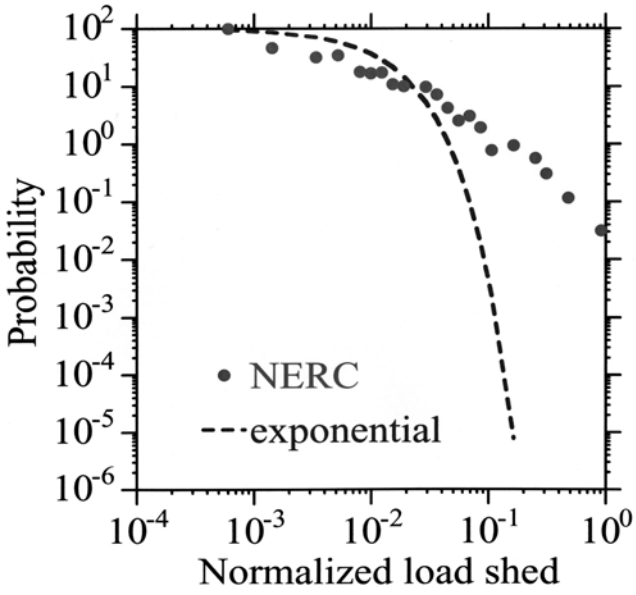


Fig. 8. Malin 500-kV voltage — recorded and simulated using WSCC data base

Actual COI Power

Blackout Risk Needs New Thinking



NERC distribution o blackout size and an exponential distribution on a log-log plot

Chaos Theory & Electric Power!

AC Power System Fundamentally Chaotic

This is Important for

- System Stability
- Ability to Predict and Anticipate Outages
- Risk and Probability of Large-Scale Outages

➢ **Need to Monitor Global Properties of System**

- Distance to Collapse

- Criticality

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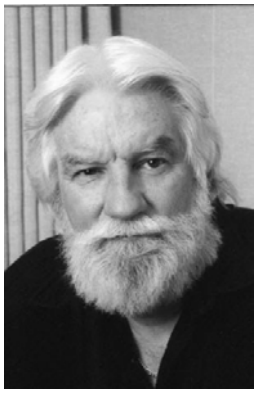

Paul Grant will continue this discussion

References

- Model Validation for the August 10,1996 WSCC System Outage**,** Dmitry N. Kosterev, Carson W. Taylor and **William A.** Mittelstadt, Transactions on Power Systems, **Vol.** 14, No. **3,** August 1999
- Eastern Interconnection Phasor Demonstration, Enhanced Wide-Area Visibility In the Eastern Interconnection for Reliability Management . Transmission Reliability Program Peer Review, Washington, D.C., Carl Imhoff
- PMU Applications Business Case Study: Results and Recommendations. Damir Novosel, Jim Cole, Lisa Beard, Eastern Interconnection Phasor Project Meeting, St. Louis, Sept., 2006

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