Transmission Technology, Policy, Reliability and the Brilliant Network or *Will the Laws of Physics Respond to Legislation and Regulation?*

Wisconsin Public Utility Institute

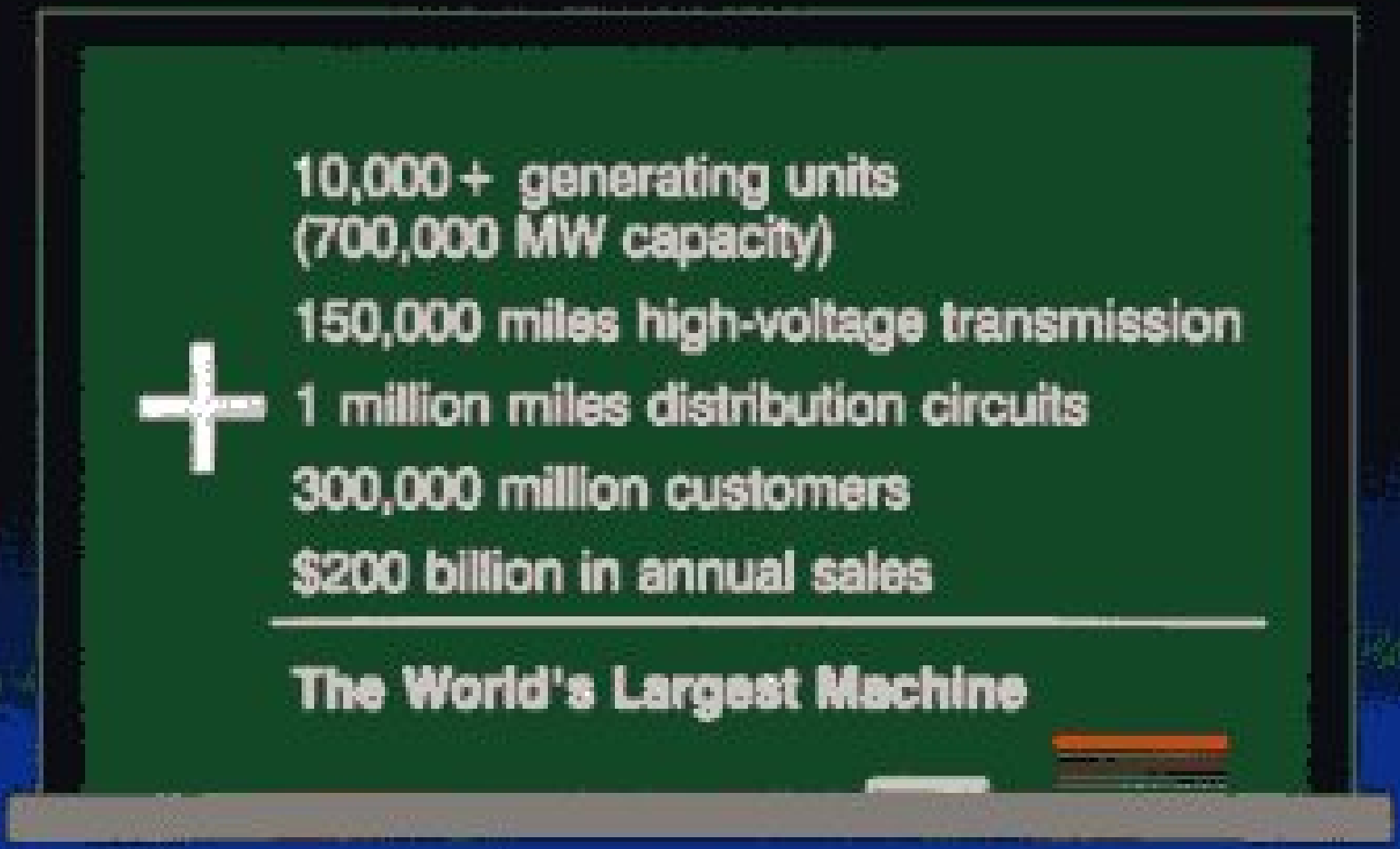
Thomas R. Schneider

December 19, 2005

What is It?

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

The North American Power System



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

New Mexico Gov. Bill Richardson

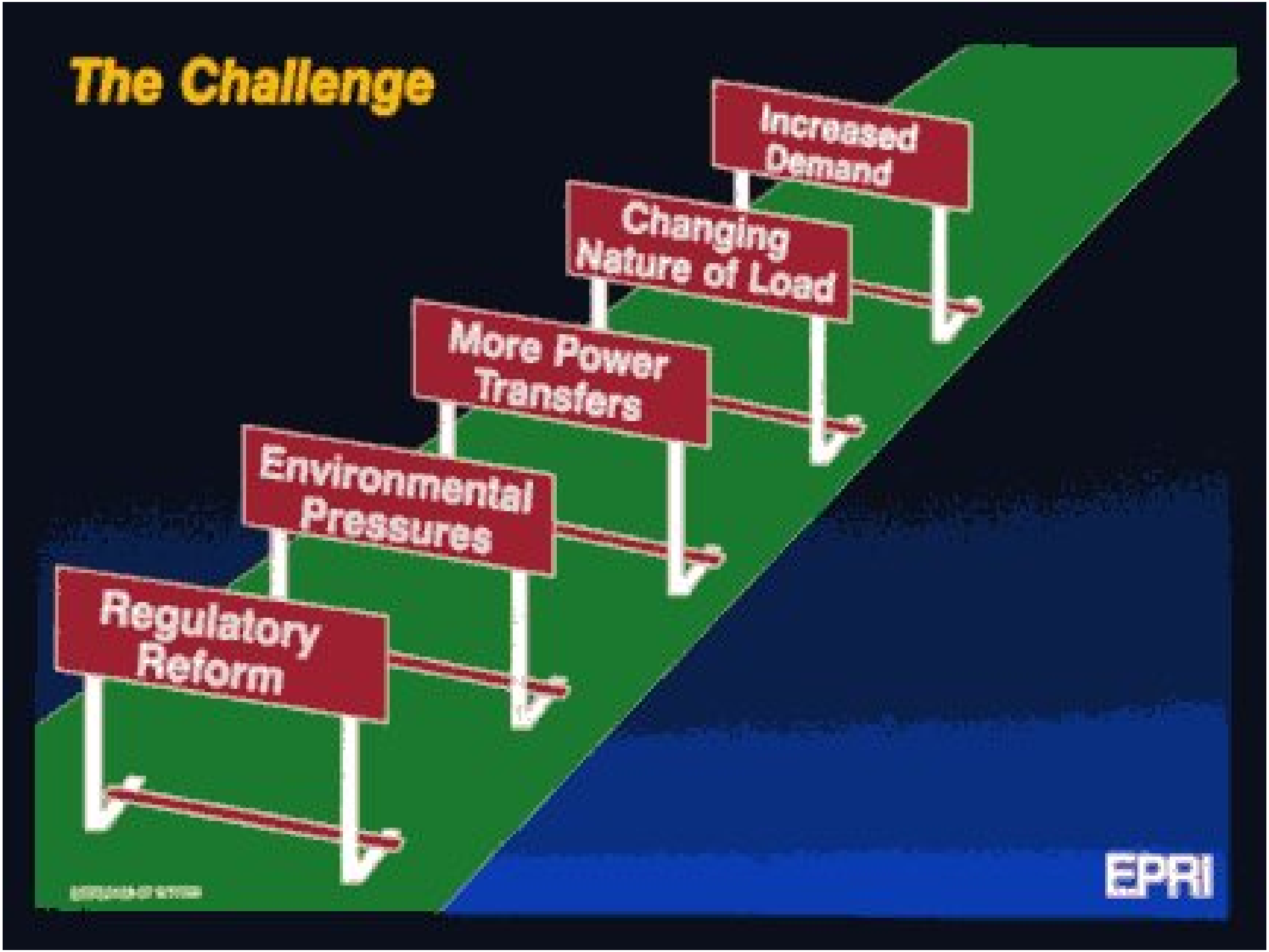
August 2005

Deregulation - Promises, Promises

- Lower Costs to Consumer and Society
  - 1999 EIA $ 20 Billion
- Releasing the forces of innovation
- Creating Freedom of Choice and New services

Results of Restructuring??

- CA Costs Of $9 + Billion
- Reliability Problems - Major Blackouts in CA ($1 to 2 Billion in 1996) and Canada – Northeast ($7 + Billion?)
- Higher Electricty prices
- Creating Freedom of Choice?
  - Green Electrons?


The Challenge
Increased Demand
Changing Nature of Load
More Power Transfers
Environmental Pressures
Regulatory Reform
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Environmental Pressures

NIMBY = Not In My Backyard

LULU = Locally Undesirable Land Use

BANANA = Build Absolutely Nothing Anywhere Near Anything

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The Challenge
NOPE
NOPE =
Not on Planet Earth
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Change Is Inevitable

New Challenges

Changes in society are limiting the availability of transmission expansion as the simplest way to meet power system delivery needs

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Power System Reliability

- Key to quality of life and economic competitiveness
- Largely ensured through robust transmission system
- Under threat as stresses to system mount

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Public Good Aspects of Electric Power

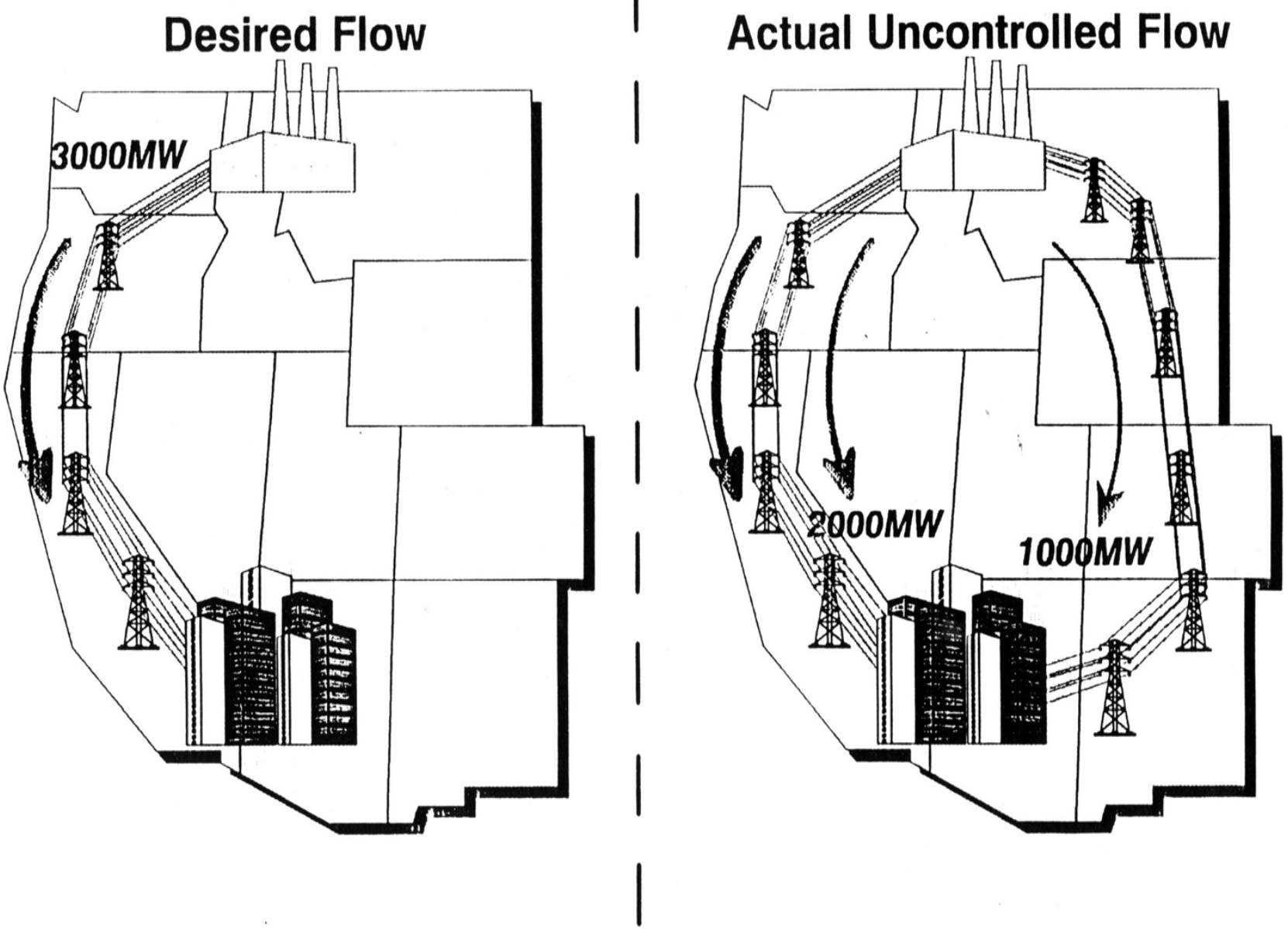
- Electricty is not a simple commidity
- Complex multi-attribute service
- Treating electricity as a simple commodity is a gross approximation
- Electric power has BOTH private and public good aspects

Public “Goods” Attributes

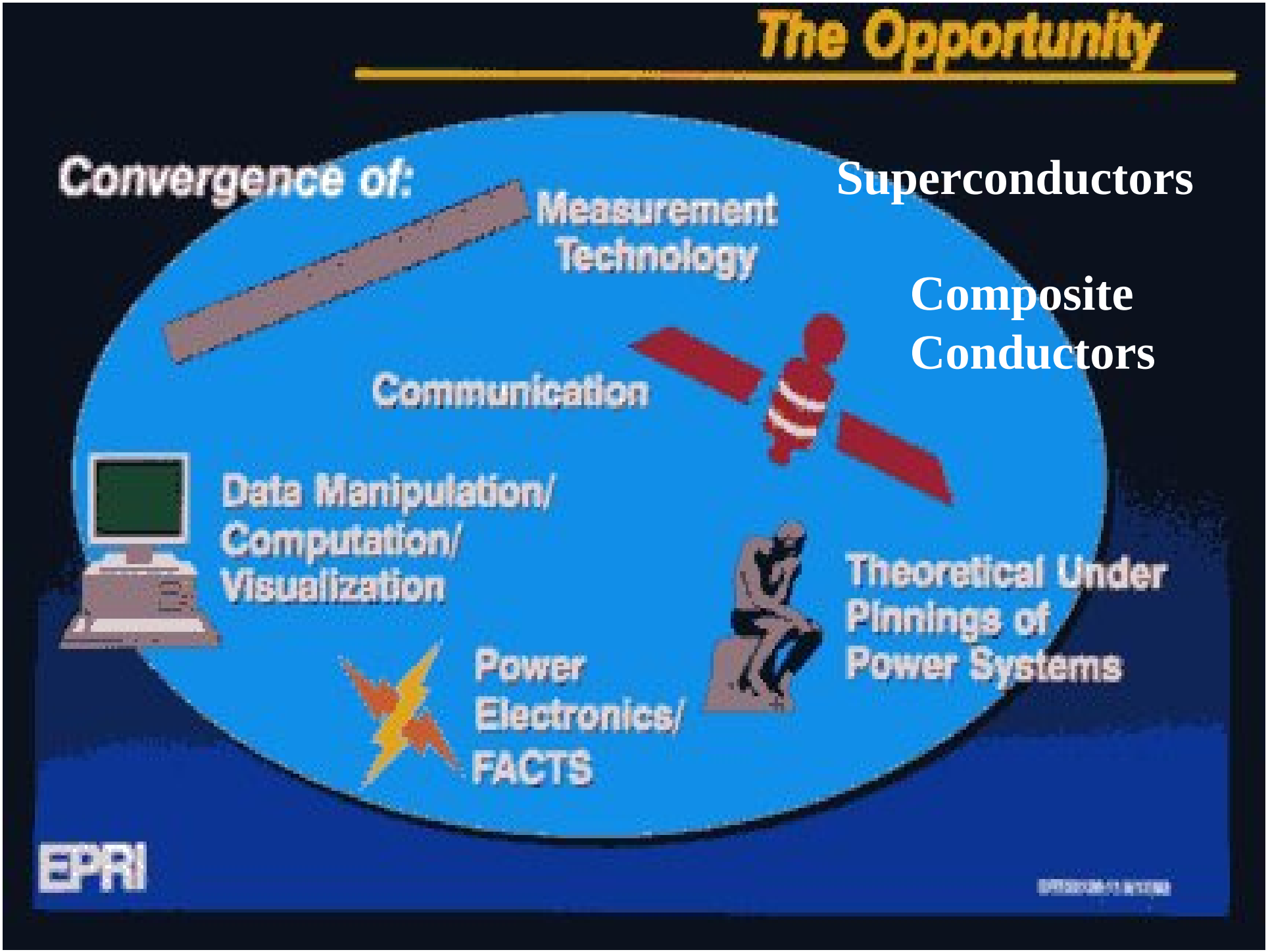
- Voltage
- Frequency
- Reliability
- Power Quality
- Losses (Real & Reactive)

Markets Do Not Efficiently Provide Public Goods

Can't Legislate Where Electrons Go



The Opportunity



Superconductors

Composite Conductors

Measurement Technology

- *Capture, measure, and analyze power system operating data*
- *Sample technologies*
  - Data acquisition tools
  - Distributed processing capabilities
  - Fiber-optic sensors
  - Laser instrumentation

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Communication Technology

- **Rapid, reliable, accurate acquisition and transmission of critical data to remote controllers**

- **Sample technologies**
  - Integrated utility communications
  - Fiber optics
  - Satellite communications

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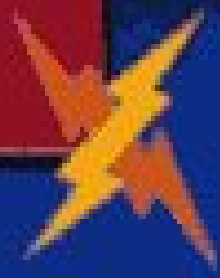
Silicon Science - FACTS

- Control flow and voltage while maintaining stability
- More power transfers
- More robust system



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Advanced Computer Capabilities

- **Better management, display, and manipulation of data for quick action**
- **Sample technologies**
  - Super computers
  - Super workstations
  - Mega chips
  - Distributed processing
  - Data visualization
  - Reinvention of analog machines

New Innovations

- Composite Aluminum Conductors for High Voltage Transmission
- Superconductors for Underground Transmission and Distribution Cables
- Superconducting Magnetic Storage (SMES) and D-SMES
- Superconducting Motors, Generators and Rotating Condensers
- Superconducting Transformers

Distributed Resources

- Advanced Diesels
- Wind Turbines
- Microturbines
- Fuel Cells
- Batteries
- Super capacitors
- Photovoltaics

New Theoretical Understanding

- Could lead to new approaches for predicting, diagnosing, and controlling system disturbances and system operations

Chaos Theory & Electric Power!

AC Power System Fundamentally Chaotic

This is Important for

- System Stablity
- Ability to Predict and Abticiapte Outages
- Risk and probability of Large scale Ourages

Need to Monitor Global Properties of System

Distance to Collapse

Criticalality

Complexity and Chaos Theory & Electric Power!

- AC Power System Fundamentally a Chaotic System. This Affects
- System Stablity
- Ability to Predict and Abticiapte Outages
- Risk and probablity of Large scale Ourages

Reliability Depends on

- Engineering design, quality construction, proper maintance and operation - Reliability is an engineered outcome,
- Unused and Unde utilized generation!
- Unused and Underutilized Transmission!

Will Competitive “Free Markets” Ever Build What is Seldom Used?

The Future Power System

New Technology Advances

Will Enable

- Cleaner, healthier, customized offices
- More comfortable, efficient homes
- More economic and efficient industry

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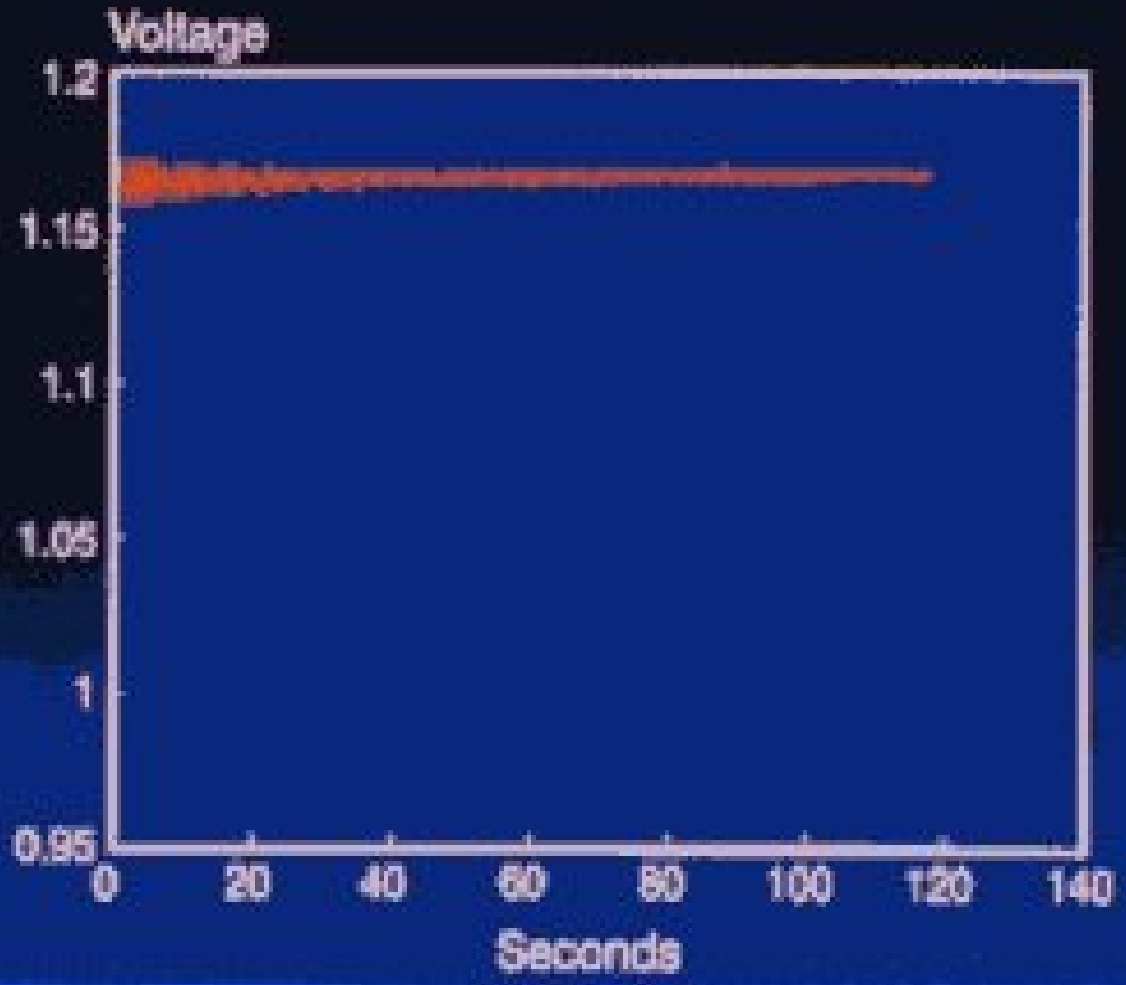
A Stable System. . .
Returns to Equilibrium



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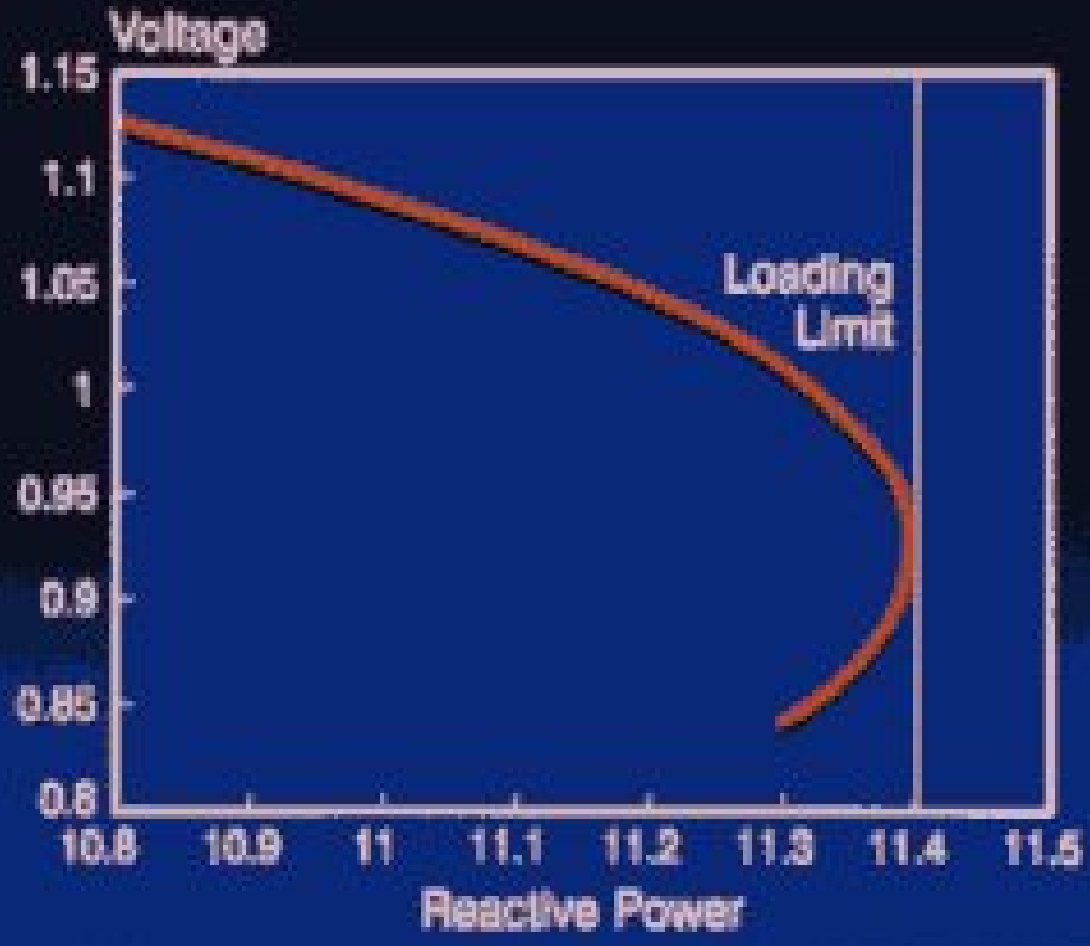
Traditional "Nose" Curve for Simple Model System



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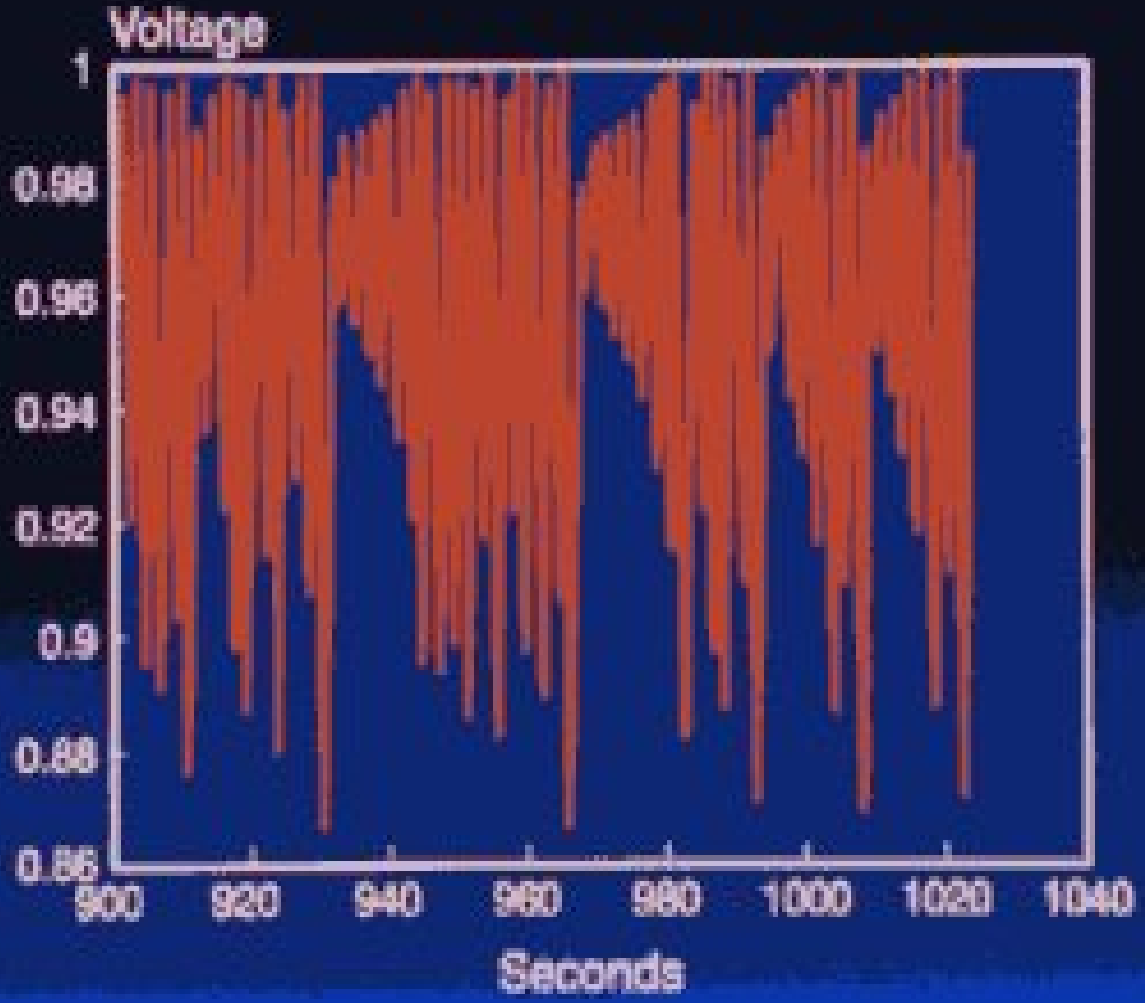
In Chaotic Region. . .
Wide Variation in Voltage



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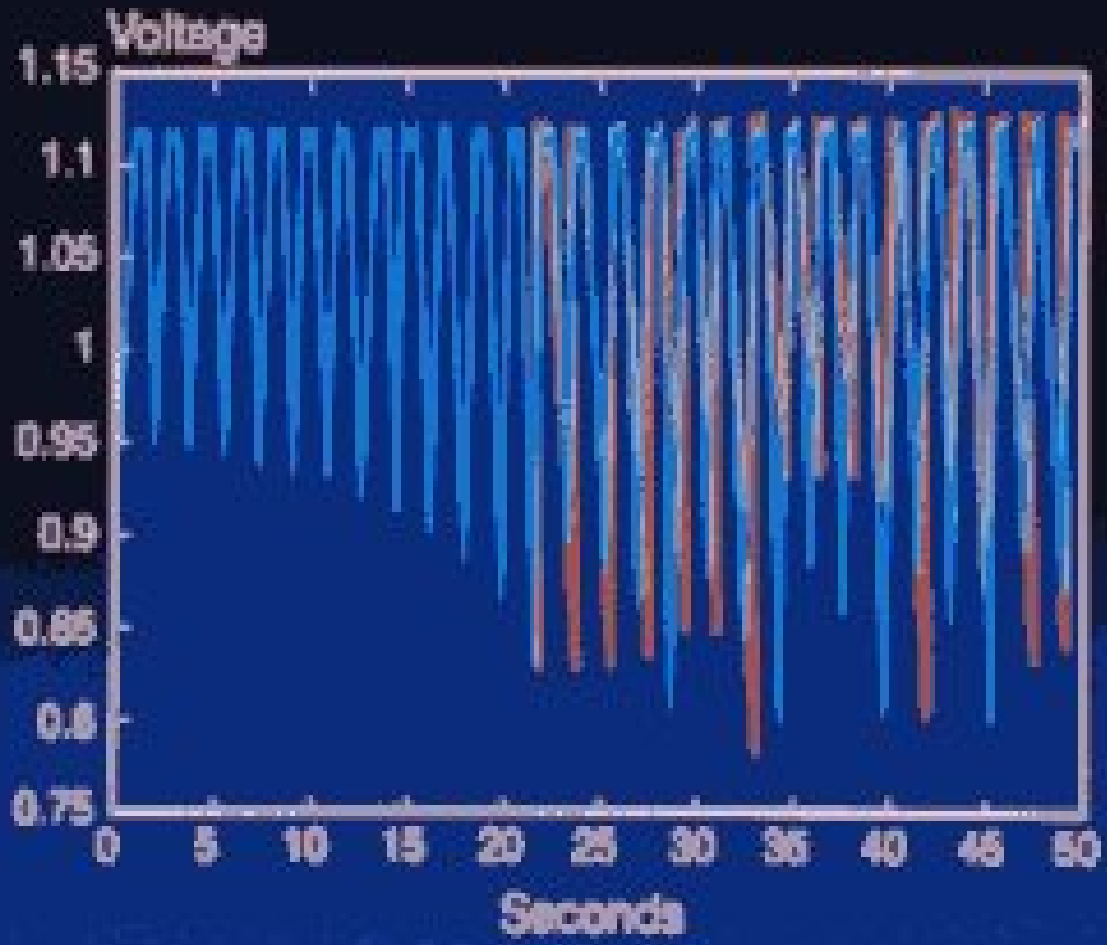
In Chaotic Region. . .
Small Initial Change Leads to Random Behavior



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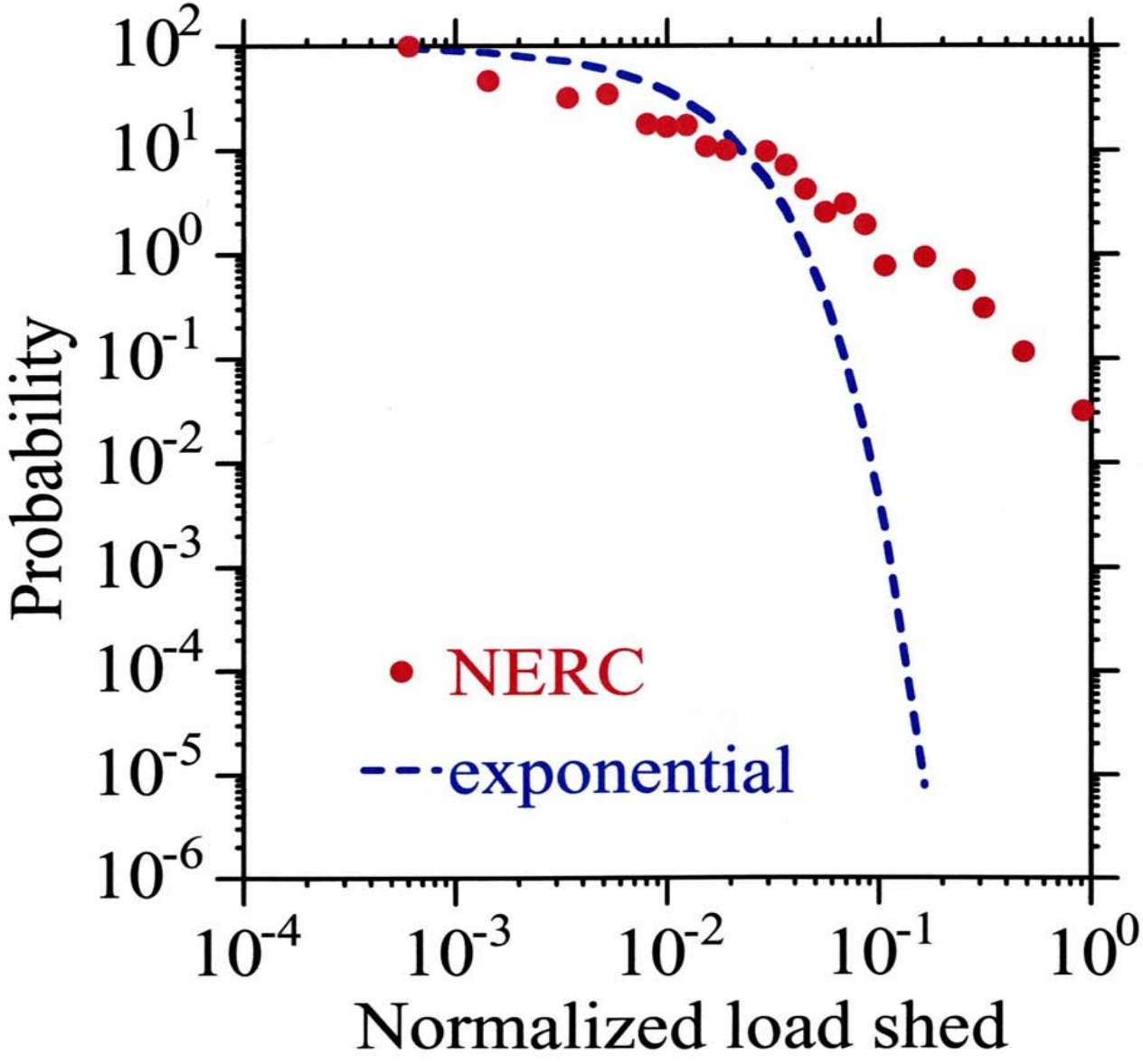
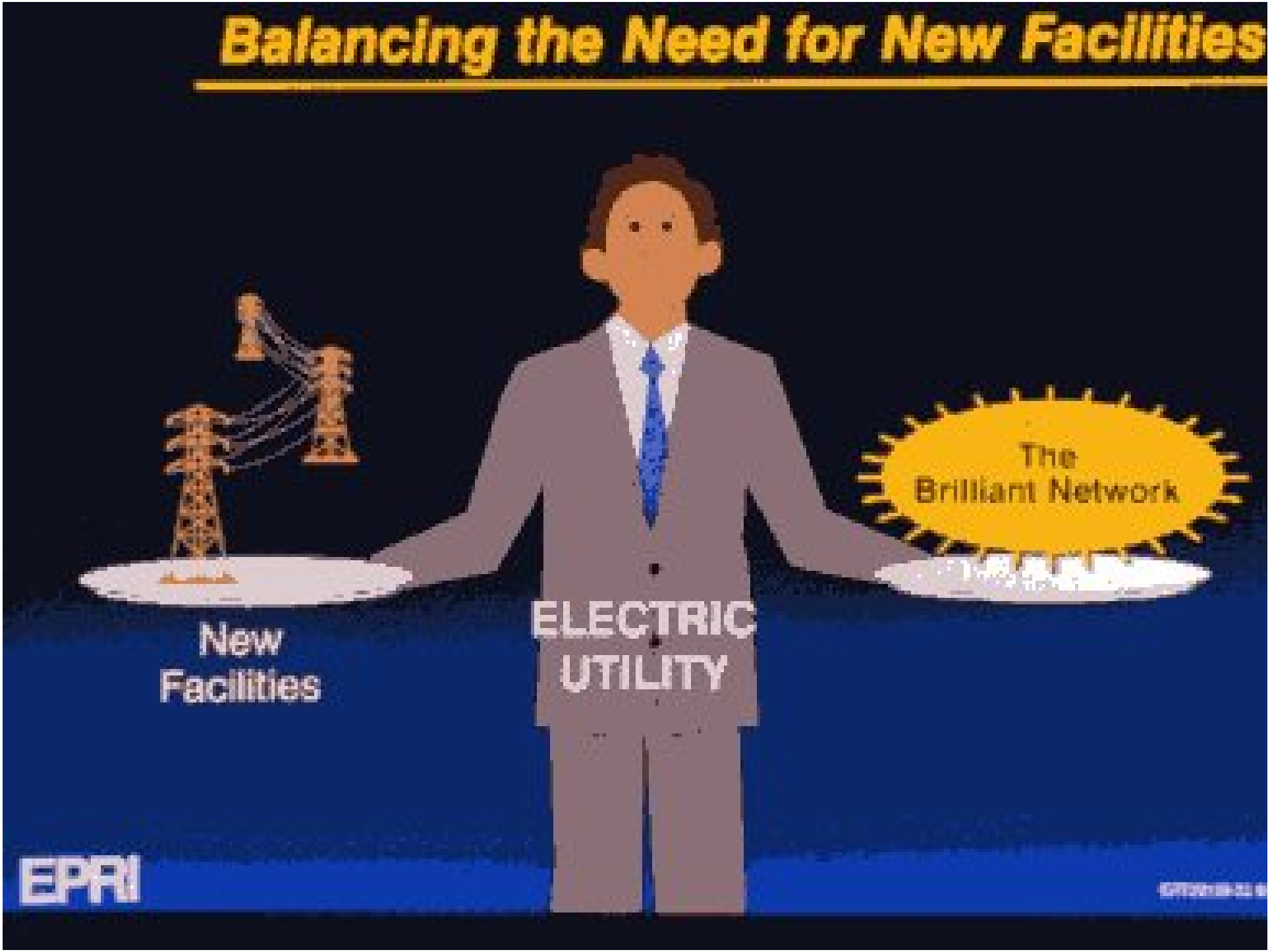
Blackout RisK Needs New Thinking



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


Balancing the Need for New Facilities
New Facilities
ELECTRIC UTILITY
The Brilliant Network
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The Benefits

Increased. . .

. . .stability without new capacity

. . .chances of survival under excess conditions

More. . .

. . .economic use of individual stations and entire system

. . .power transfers

. . .competitive exploitation of system

. . .integration of nontraditional resources

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More Competitive

More Environmentally Acceptable

More Responsive

More Efficient!

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Comments on Federal Legislation

- Energy Policy Act of 1992
- Energy Policy Act of 2005

What are the primary responsibilities of Congress?

- Representation
- Legislation
- Oversight

Where does Science Fit in Congress?

- Politics
- Procedures
- Policy

- Science is not something congress normally does…..
- Most often Congress delegates science to others

Energy Policy Act of 1992

Who imagined the consequences from such small changes?

Energy Policy Act of 1992

(H.R. 776)

`(e) **EXEMPTION OF EWGS-** An exempt wholesale generator shall not be considered an electric utility company under section 2(a)(3) of this Act and, whether or not a subsidiary company, an affiliate, or an associate company of a holding company, an exempt wholesale generator shall be exempt from all provisions of this Act

Energy Policy Act of 1992

(H.R. 776)

`(b) **UTILITIES TO PROVIDE WHOLESALE TRANSMISSION SERVICES-** Whenever-….the Commission shall issue an order requiring each such transmitting utility (and each affiliate thereof which provides wholesale transmission service in a service area directly affected by the covered sale, merger, or consolidation, as determined by the Commission), to provide wholesale transmission services in accordance with this section and section 212. An order under this section shall include tariffs of general applicability for the transmission services to be provided and shall include such other terms and conditions as necessary pursuant to section 212.

Energy Policy Act of 2005

More than Five Years in a Sausage factory

Major Section Apply To Electric Power

EPAct 2005 Affects Transmission

- Mandatory, enforceable reliability standards
- Federal “backstop” siting authority
- Incentive-based rates
- 15 year transmission asset tax life
- Revisions to Public Utility Regulatory Policy Act
- Low voltage dry-type distribution transformer efficiency standard
- FERC to encourage new transmission technologies

Reliability
Before EPAct 2005

North America Reliability Council

FERC

State Commissions

Utility

Consumers themselves

Reliability Standards Before EPAct 2005

- NERC Organized After 1965 Blackout
- NERC prepares standards via ANSI process
- Voluntary compliance via regional ERCs
- Major utilities pledged to comply
- FERC makes mandatory via OATT
- FERC has no authority over non-investor owned utilities
- Major utilities pledged to comply

Reliability Standards After EPAct 2005

- FERC to Establish independent ERO
- ERO to propose standards to FERC and enforce standards
- FERC to approve or remand standards
- Transmission operators may appeal enforcement actions to FERC
- FERC gets reliability authority over large government utilities
- This only covers *operational reliability*, not *adequacy. **Not** planning Responsibility*

Siting Before EPAct 2005

- States have siting authority
- States have limited incentive to approve transmission facilities for interstate commerce
- Transmission Lines oftrn delayed 15 or more years
- Some delayed Lines liked to Blackouts
- Secretary of Energy does have some authority in emergencies to energize lines

EPAct 2005 Provides Federal Transmission Siting Authority

- DOE to designate National Interest Electric Transmission Corridors; DOE may consider
  - Economic vitality & development
  - Economic growth
  - Supply diversity
  - US energy independence
  - National energy policy interest
  - National defense & homeland security
- FRTC must issue rules for the siting application process

Federal Backstop Siting Post-EPAct 2005

May issue construction permits in NIETCs if

- States don't have authority to approve siting or cannot consider interstate benefits
- The applicant cannot apply to the state in the NIETC because it does not serve customers in the state
- States with authority have held up approval for 1 year after application or 1 year after NIETC designation; or conditioned the permit so it would not reduce interstate congestion or make the project economically infeasible

Federal Backstop Siting Post EPAct 2005 (Continued)

- FERC may issue permits for construction or modifications in NIETCs if (con't)
  - Facilities will used for interstate commerce
  - Proposal is in the public interest
  - Facility will significantly reduce interstate congestion
  - Facility will enhance energy independence
  - Proposal maximizes the use of existing towers and structures

FERC Is to Encourage Advanced Technologies

1) high-temperature lines (including superconducting cables);
2) underground cables;
3) advanced conductor technology (including advanced composite conductors, high-temperature low-sag conductors, and fiber optic temperature sensing conductors);
4) high-capacity ceramic electric wire, connectors, and insulators;

FERC Is to Encourage Advanced Transmission Technologies

5) optimized transmission line configurations (including multiple phased transmission lines);
6) modular equipment;
7) wireless power transmission;
8) ultra-high voltage lines;
9) high-voltage DC technology;
10) flexible AC transmission systems;

FERC to Encourage Advanced Transmission Technologies

11) energy storage devices (including pumped hydro, compressed air, superconducting magnetic energy storage, flywheels, and batteries);

12) controllable load;

13) distributed generation (including PV, fuel cells, and microturbines)

FERC to Encourage Advanced Transmission Technologies

14) enhanced power device monitoring;

15) direct system state sensors;

16) fiber optic technologies;

17) power electronics and related software (including real time monitoring and analytical software);

18) mobile transformers and mobile substations; and

19) any other technologies the Commission considers appropriate.

Incentive-Based Rates

FERC shall prescribe a rule on incentive-based, including performance, transmission rates that

- Promotes reliable and economically efficient transmission & generation by promoting capital investment in enlargement, improvement, maintenance & operation of all transmission facilities
- Provides a return on equity that attracts new investment
- Encourages technologies that increase capacity & efficiency
- Recovers costs for meeting reliability standards and federal siting

Transmission Tax Depreciation

- Life for transmission facikities at and above 69 kV or more contracted for and placed in service after 4/11/05 is reduced to from 20 to 15 years
- Distribution assets still have 20-year tax life)
- Transmission assets are from generator bus bar to high side of the distribution substation

Repeal of PUHCA

- Contained in Energy Policy Act of 2005
- Effective 6 months after enactment
- Regulations to be issued by FERC within 4 months after enactment, but not in regard to PUC access to books and records
- Availability of books and records of holding, associate and affiliate companies to FERC and state PUCs subject to terms and conditions as may be needed to prevent unwarranted disclosure of trade secrets and commercial information

Repeal of PUHCA

- Coupled with enhanced FERC merger review Includes prohibition on FERC members and staff divulging confidential information
- In case of State PUC's, the production of books and records is subject to terms and conditions as may be needed to prevent unwarranted disclosure of trade secrets and commercial information
- No transition rules

FERC Merger Review

- Amends section 203(a) of Federal Power Act to expand FERC review of utility mergers
- Effective 6 months after enactment
- Increases threshold to $10MM
- FERC merger authority over holding companies made statutory

FERC Merger Review

- Mandates approval of transaction if FERC finds it consistent with broad standard of public interest and will not result in cross subsidization or pledge or encumbrance of utility assets for non-utility purposes, unless FERC determines such will be consistent with public interest
- Requires FERC action within 180 days of application, with one extension for good cause of up to 180 days

FERC Merger Review

- Transition rule is that any transaction that would otherwise be subject to section 203(a) as amended is not subject to amended section if filed before enactment
- Enhanced merger review was tied to PUHCA repeal in Senate to gain
- bipartisan support for repeal

PURPA Section Includes

- Market based rates for new PURPA generation contracts
- Time of use rates and associated metering
- Connection of distributed generation in accordance with IEEE-1547
- All PURPA provisions are strongly impacted by state policy

Nation's Economy Still at Risk

Restructuring is a real time experiment re-designing an entire industry. An industry that represents roughly 5% of the GDP. If these experiments fail then the entire economy is at risk.

Invest for the Future

- Invest un **Research**, focus on fundamental understanding of power systems and market economics
- Invest in **Transmission**, focus on creating incentives for long-term transmission investment
- Invest in **Reliability**, focus on the national Electric Reliability Organization (ERO) started and seek mechanisms for long-term investment in reliablity

Invest in Research

- Research in Power Systems is woefully under funded – especially fundamental research in the “global” behavior of large power systems.
- Support and strengthen research here at Madison and nationally
- Fight for significant federal funding so we can learn from our mistakes and not be doomed to repeat them.

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Invest in Research

“The recurring message is that technology in use today will not be adequate to meet the needs of the emerging competitive system.+

1997 IEEE-USA Technology Policy Symposium Executive Summary
June 11, 1997

Invest in Research

"A new discipline combining electrical engineering with market economics is needed. All this will require a new breed of power systems engineer to accommodate the new ways of doing business and creating solutions to the new engineering and economic problems."

1997 IEEE-USA Technology Policy Symposium
Executive Summary June 11, 1997

Invest in Research

"It is best to experiment with computational models and experimental econoic simulations rather than on the real systems thus impacting the customers. It is urgent that a near-term focus of our research be on the underlying engineering and economic science and accurate simulation of the power system as a decentralized and open marketplace."

Invest in Transmission

- Structural cahnges and regulatory and financal retirn uncertainty has lead to a serious decline in transmission investment
- But demand growth continues
- Unless changes are made, blackouts will become increasing,y common.

Invest in Transmission

"Better ways to operate transmission and distribution systems, not generation, offer the major technological challenges of restructuring. New and improved transmission, communication, control and metering technologies and systems need to be developed. Information exchange and system simulation capabilities, both predictive and real-time, are essential to assure the security and reliability of the new market-based system operation."

1997 IEEE-USA Technology Policy Symposium
Executive Summary June 11, 1997

Invest in Transmission

"A successful marketplace will naturally encourage the development of efficient generation. However, if the capacity, control and operation of the transmission system are mismanaged or inadequate for supporting a competitive market, then any savings that accrue as a result of increased generation efficiency will be lost."

1997 IEEE-USA Technology Policy Symposium
Executive Summary June 11, 1997

Invest in Transmission

- LMP and congestion charges do not create the right incentive for Transmission Investment
- Markets are not good at providing “Public Goods” such as reliability – mandatory regulations are needed.
- Rethink the nature of the institution(s) that provide transmission and system operation and their regulation

Invest in Reliability

- The new ERO is critically important
- Standards Must Deal with Current Reality
- Consistent Standards are Required
- Reliability and Market Rules Must be Compatible
- Reliability Requires Information Access
- Regulations and Technical Fundamentals Must be Compatible
- Long-Term Resource Adequacy Must be Ensured

Invest in Reliability

"The marketplace for electricity is created by the interconnected transmission system. For prices to fall, the marketplace enabled by the transmission system must be highly competitive. For the system to function reliably, competing companies must cooperate."

Thank You!

Energy Policy Act of 2005 is PUBLIC LAW 109–58—AUG. 8, 2005 and can be found on http://www.access.gpo.gov/index.html

Information on IEEE Energy Policy Committee can be found at http://www.ieeeusa.org/volunteers/committees/EPC/

The Power System Engineering Website is http://www.pserc.wisc.edu/

TRSenergy@AOL.com

Back-Up Slides

FERC Technical Conference

Docket No. RM05-30-000

Talking Points of:
Richard A. Wakefield
Past Chair, IEEE-USA Energy Policy Committee

November 18, 2005

Based on a position Developed by IEEE-USA Energy Policy Committee

- Developed by members of the IEEE-USA Energy Policy Committee (EPC)
- Stated in 2004 Position Statement: Principles for a Restructured Electric Industry (copies available)
- EPC's overall objective is "…to assist in the resolution of energy problems through the provision of rational, sound, technical and professional counsel…"

ERO Standards Must Deal with Current Reality

- There are many visions of the correct utility industry structure,
- BUT, We must deal with the structure that exists now and in the near future
  - Diverse in structure
  - Regionally-differentiated

Consistent Standards are Required

- Reliability criteria established by ERO should be the minimum applied by all systems, regardless of the regulatory regime.
  - Criteria should apply to all market participants
  - State and Federal policymakers should recognize these criteria

Reliability Rules and Market Rules Must be Compatible

- When market rules work against reliability rules, problems are inevitable.
- Incompatibilities should be scrutinized and resolved, with all views considered.

Reliability Requires Information Access

- Reliability rules must ensure that accurate information is available on a timely basis for:
  - Long-term system development
  - Operational planning
- Commercially sensitive information must be protected

Long-Term Resource Adequacy Must be Ensured

- Requirements should apply to both integrated and restructured systems.
- Compliance mechanisms may differ.
- Both real and reactive power adequacy should be considered.

Regulations and Technical Fundamentals Must be Compatible

- Electric systems have unique characteristics
- Standards development process should include technical competent:
  - Drafters
  - Reviewers

Conclusions

- These guidelines are a set of minimum requirements.
- Developing standards that adhere to these guidelines will not be easy.
- Process must be open, rigorous and flexible.
- Revisions will be required as industry evolves.

Questions for Power Lunch Participants: Technology

- Which types of technologies exist and how commercially ready are they?
- What are the costs and risks involved in updating current systems?
- How can these technology developments overcome the issues of NIMBY, environmental impacts, and customer rate-based cost-recovery?

Questions for Power Lunch Participants: Technology

- Which federal and state policy developments are needed to support advanced transmission technologies?
- How do regulatory policies assist or hinder transmission improvement?

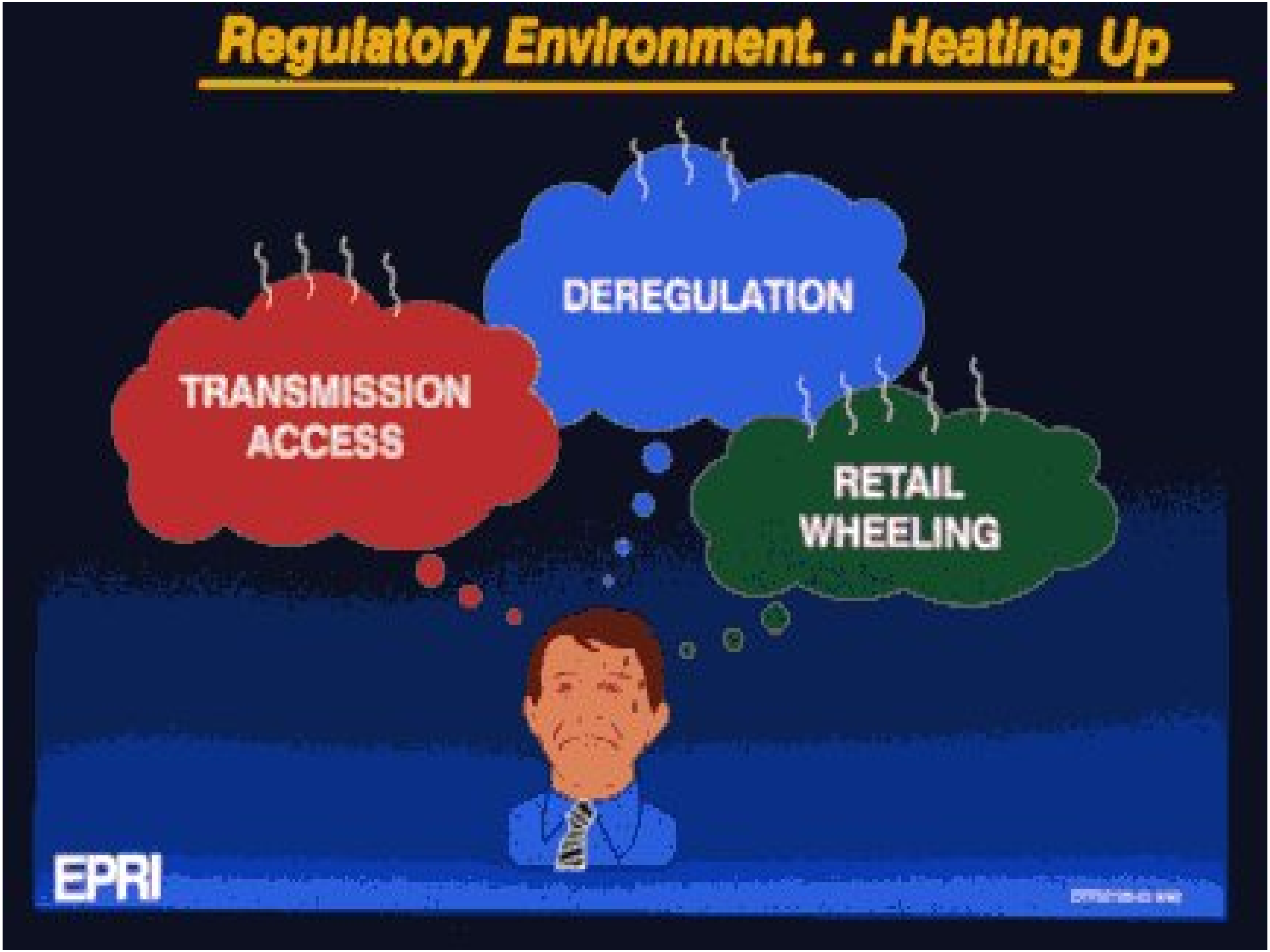
Questions for Power Lunch: Investment

- What incentives do utilities have to invest in transmission infrastructure?
- Who should invest in transmission improvements?
- How can the market produce better investment options?

Questions for Power Lunch: Local

- Instead of transmission improvements, should we promote distributed generation as a local load development method?
- How does Wisconsin's transmission infrastructure compare to other states', and how might this affect potential developments?

Regulatory Environment. . .Heating Up



Environmental Concerns

PRESSURES ON UTILITIES WILL KEEP GROWING

- **International Community**
  - . . . CO_2 /Global Warming
- **EPA Efficiency Initiatives**
  - . . . Green Lights, Golden Carrot, etc.
- **Clean Air Act Amendments**
  - . . . SO_2 cap - maybe soon on NO_X, toxics, particulates too
- **National Energy Strategy Legislation**
  - . . . IRP to include "external" costs

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Large Scale Blackouts are Fast

Cumulative Line Trips from August 2003 Blackout Final Report

Figure 6.1. Rate of Line and Generator Trips During the Cascade