

CHALLENGES AND OPPORTUNITIES IN THE NEW TRANSMISSION BUSINESS

presentation by

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LIVING IN INTERESTING TIMES

- ❑ The business has never been more exciting
- ❑ Restructuring presents a range of unprecedented opportunities and set of daunting challenges
- ❑ Problems require interdisciplinary approaches

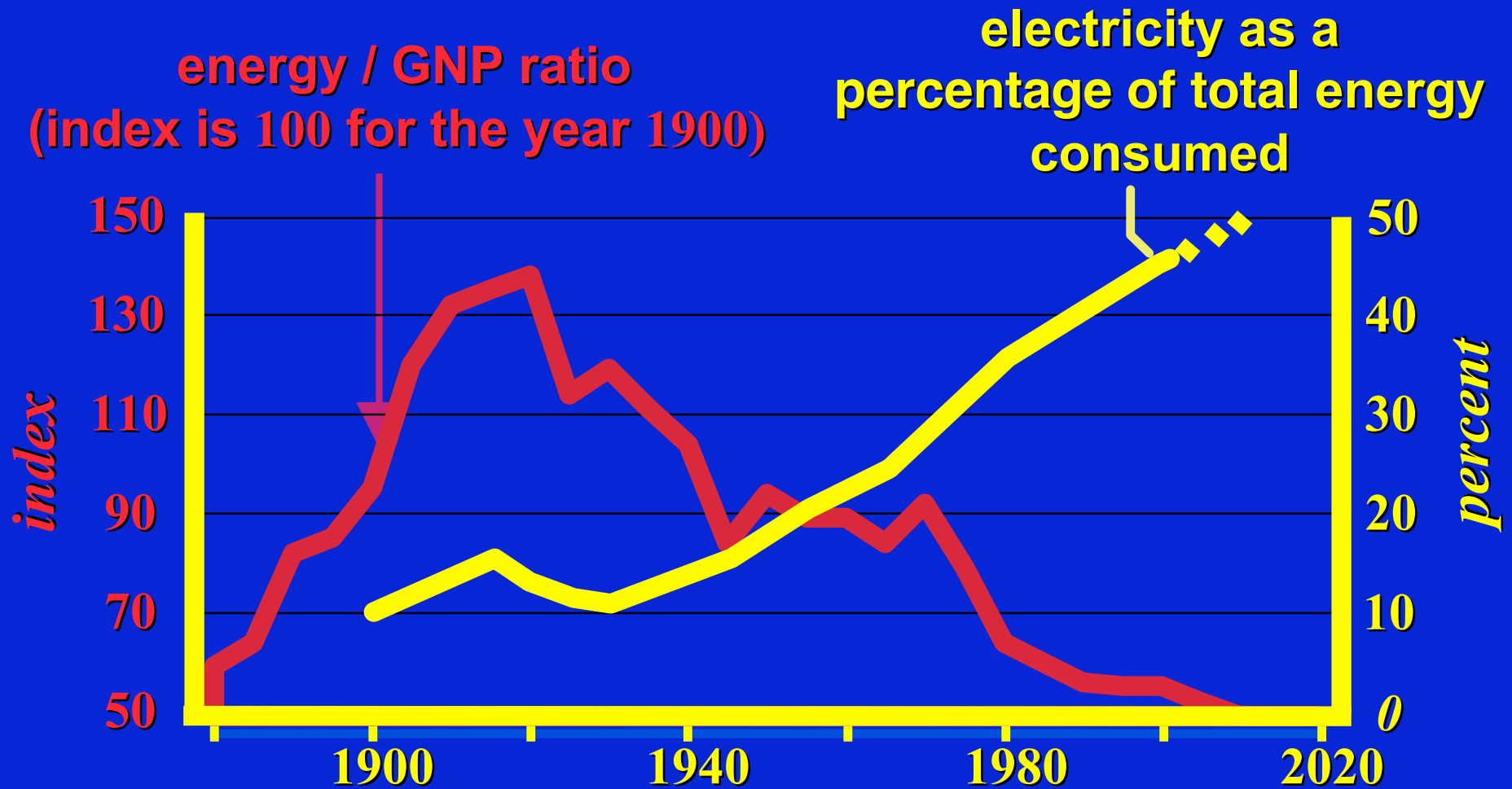
OUTLINE

- ❑ The growing importance of electricity
- ❑ Evolving role of transmission services
- ❑ The 2003 U.S. Blackout
- ❑ Some key challenges and opportunities
- ❑ Training needs

CRITICAL IMPORTANCE OF ELECTRICITY

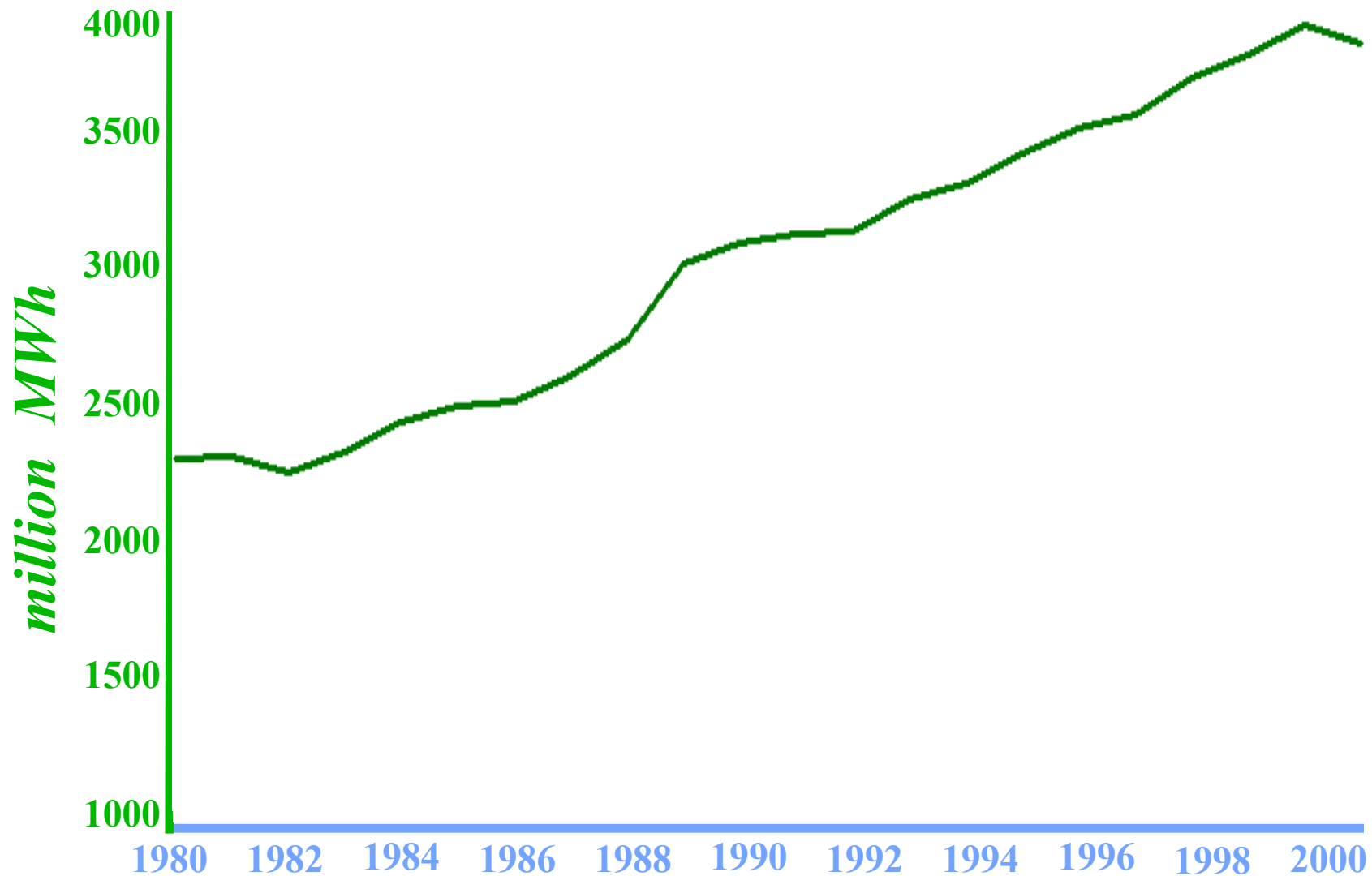
- ❑ **Energy is the lifeblood of modern society**
- ❑ **The importance of electricity is on the rise**
- ❑ **Efficient and environmentally sensitive electricity services are key requirements for each nation's global competitiveness**

ENERGY CONSUMPTION AND ELECTRICITY USE



electricity will continue to substitute for less efficient and less productive energy forms

U.S. ELECTRIC ENERGY SALES AND CO₂ EMISSIONS



Source: Energy Information Administration, U.S. Department of Energy

IMPACTS OF ELECTRICITY

- ❑ The National Academy of Engineering, the U.S.'s most prestigious collection of outstanding engineers, named **electrification** -- the development of the vast networks of electricity that power the world -- the most important of the twenty engineering achievements that have had the greatest impact on the quality of life in the 20th century

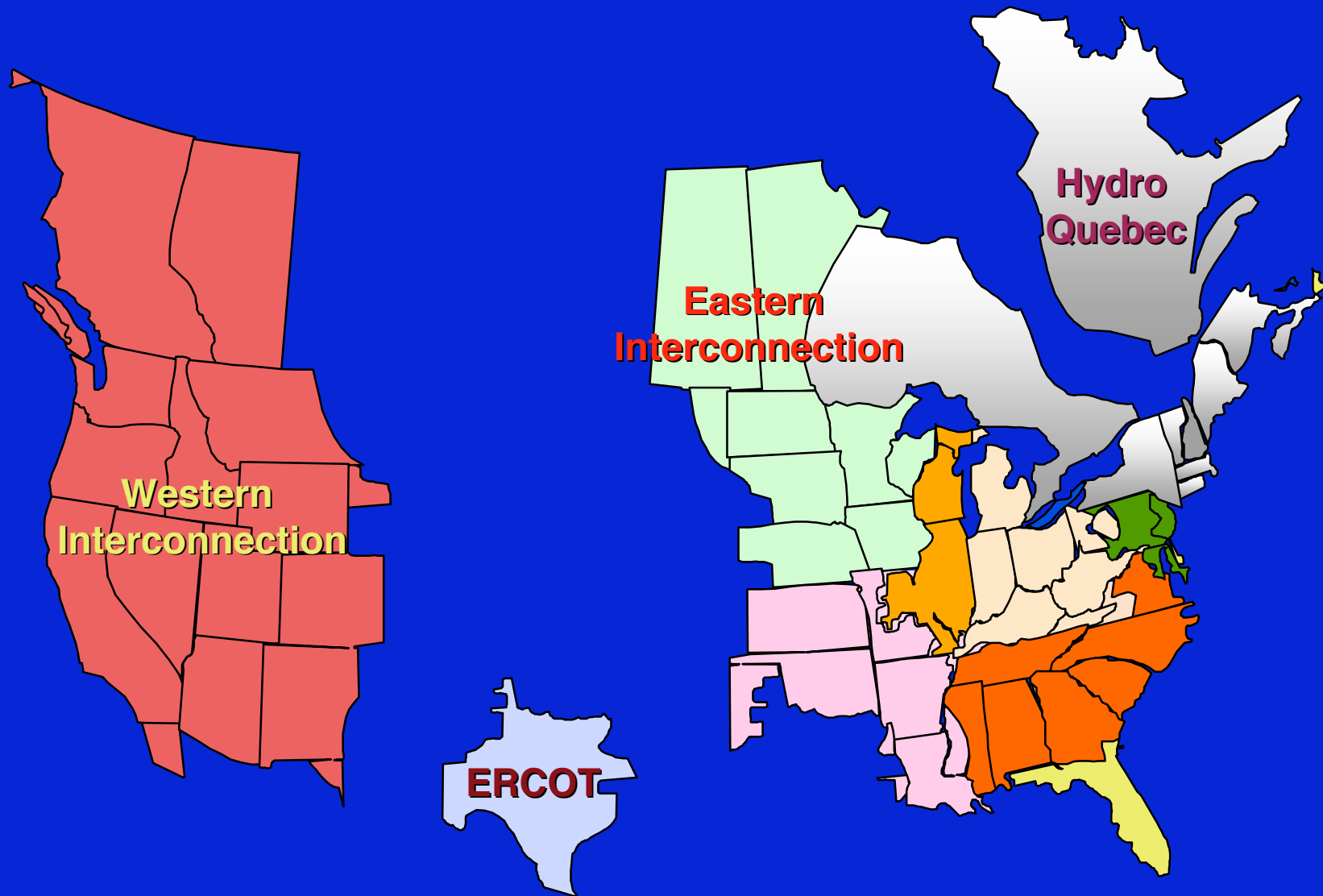
IMPACTS OF ELECTRICITY

- ❑ Electricity ranked ahead of the automobile, airplane, safe and abundant water, electronics, computers and space exploration
- ❑ The widespread electrification implemented in the 20th century gave us power for our cities, factories, farms and homes, forever changing the lives of people

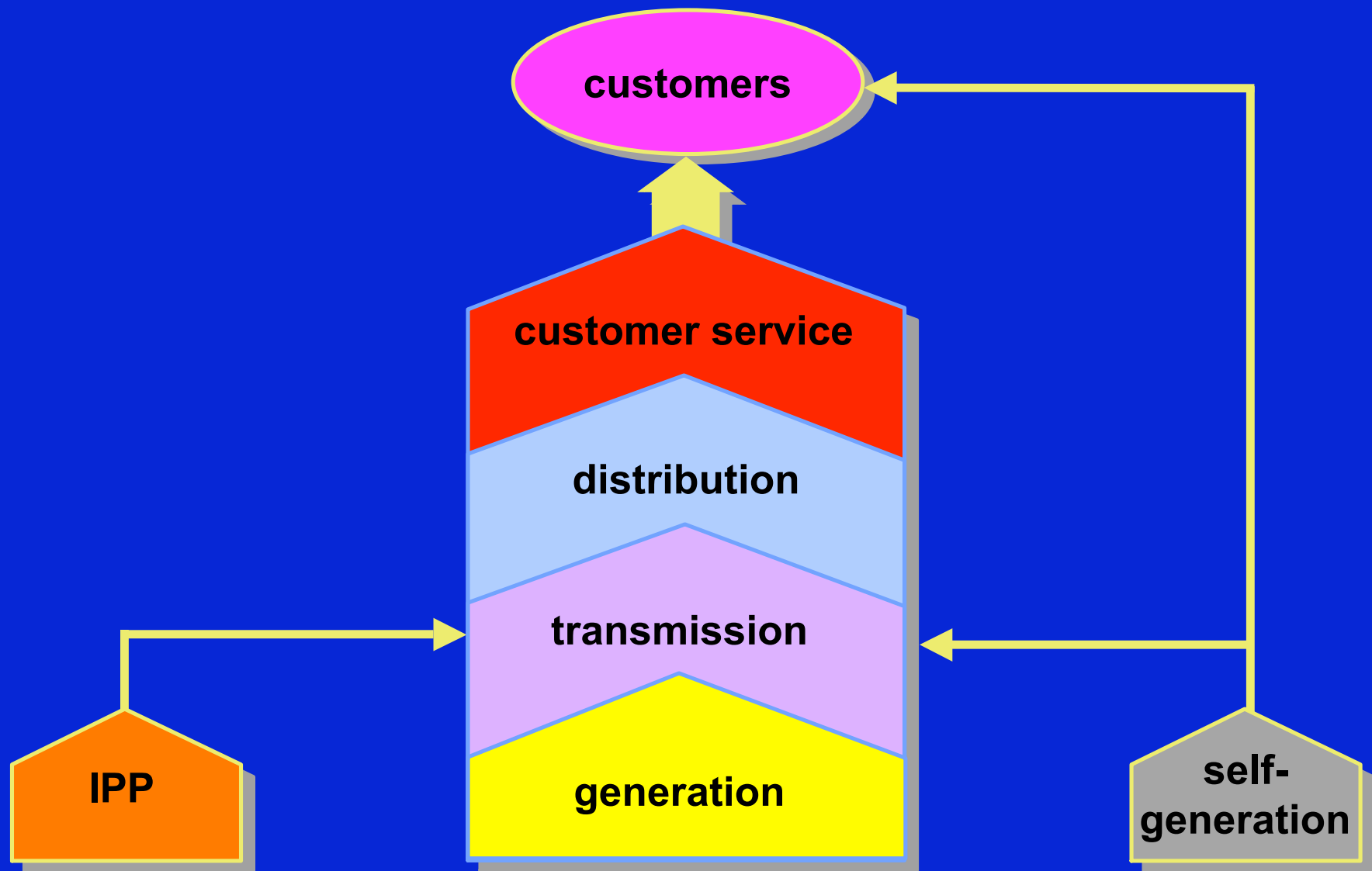
THE UNIQUE CHARACTERISTICS

- ❑ Lack of large-scale storage
- ❑ Extreme *perishability* of electricity: *just-in-time* manufacturing process
- ❑ *Obligation to serve* requirement : no analogue to the busy signal in communications systems

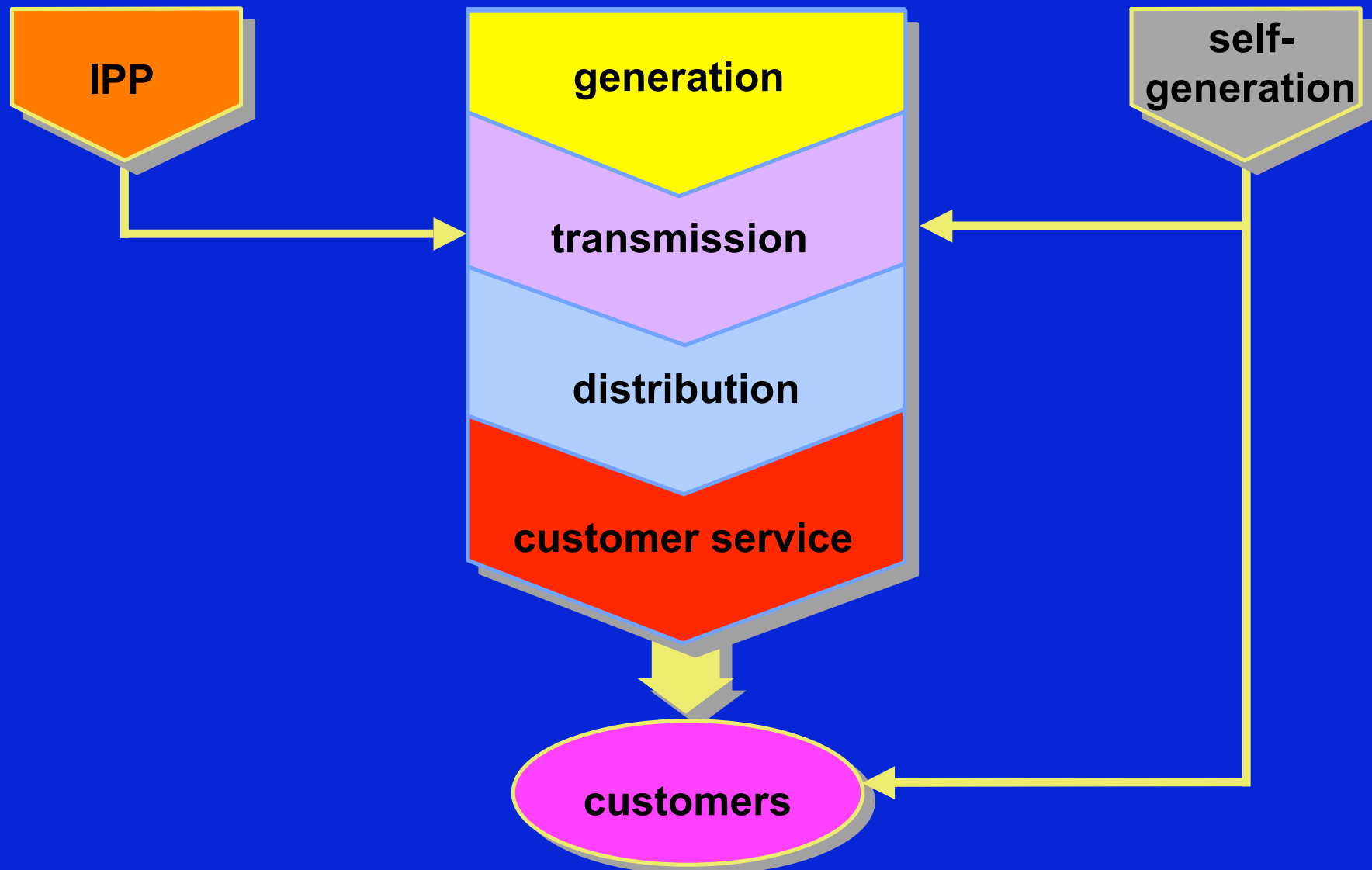
THE NORTH AMERICAN GRIDS



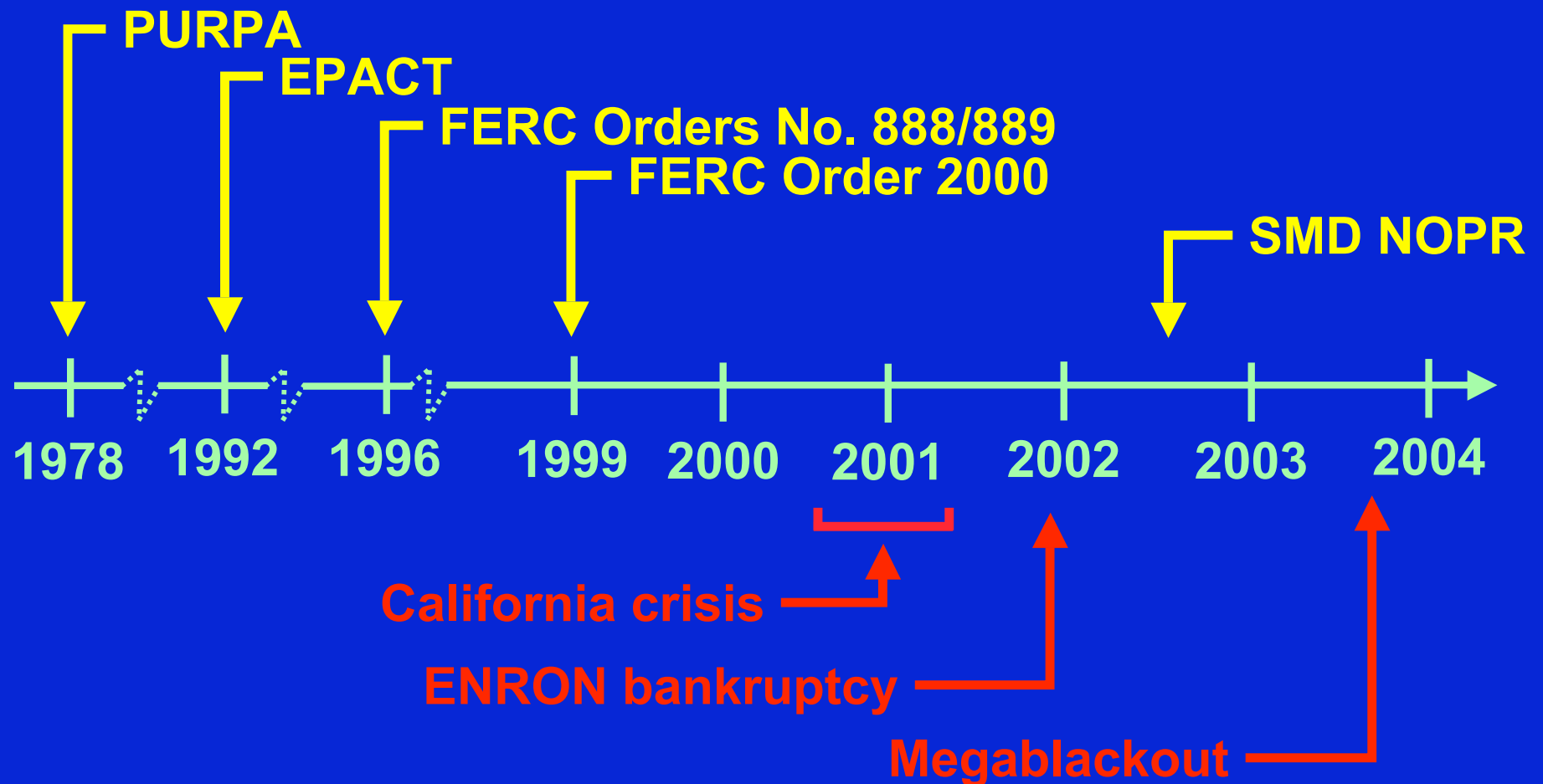
THE VERTICALLY INTEGRATED UTILITY INDUSTRY STRUCTURE



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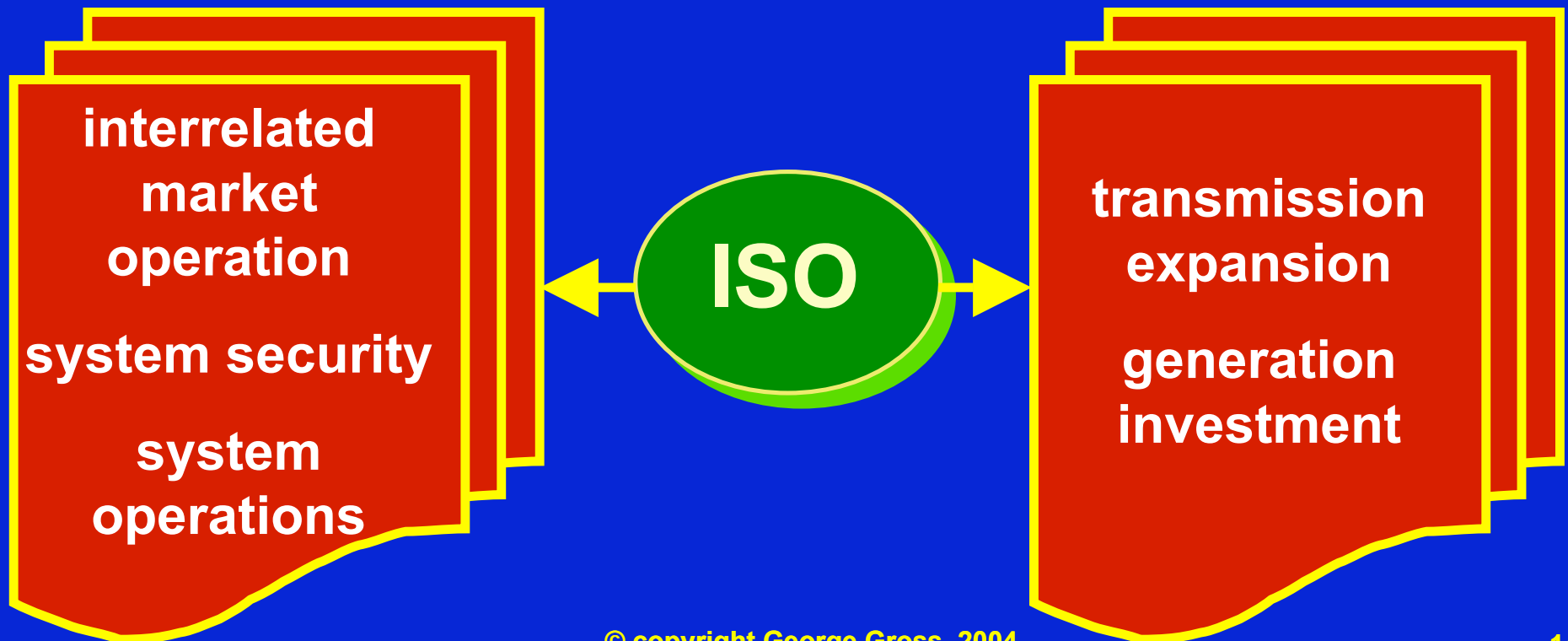


KEY DEVELOPMENTS IN RESTRUCTURING

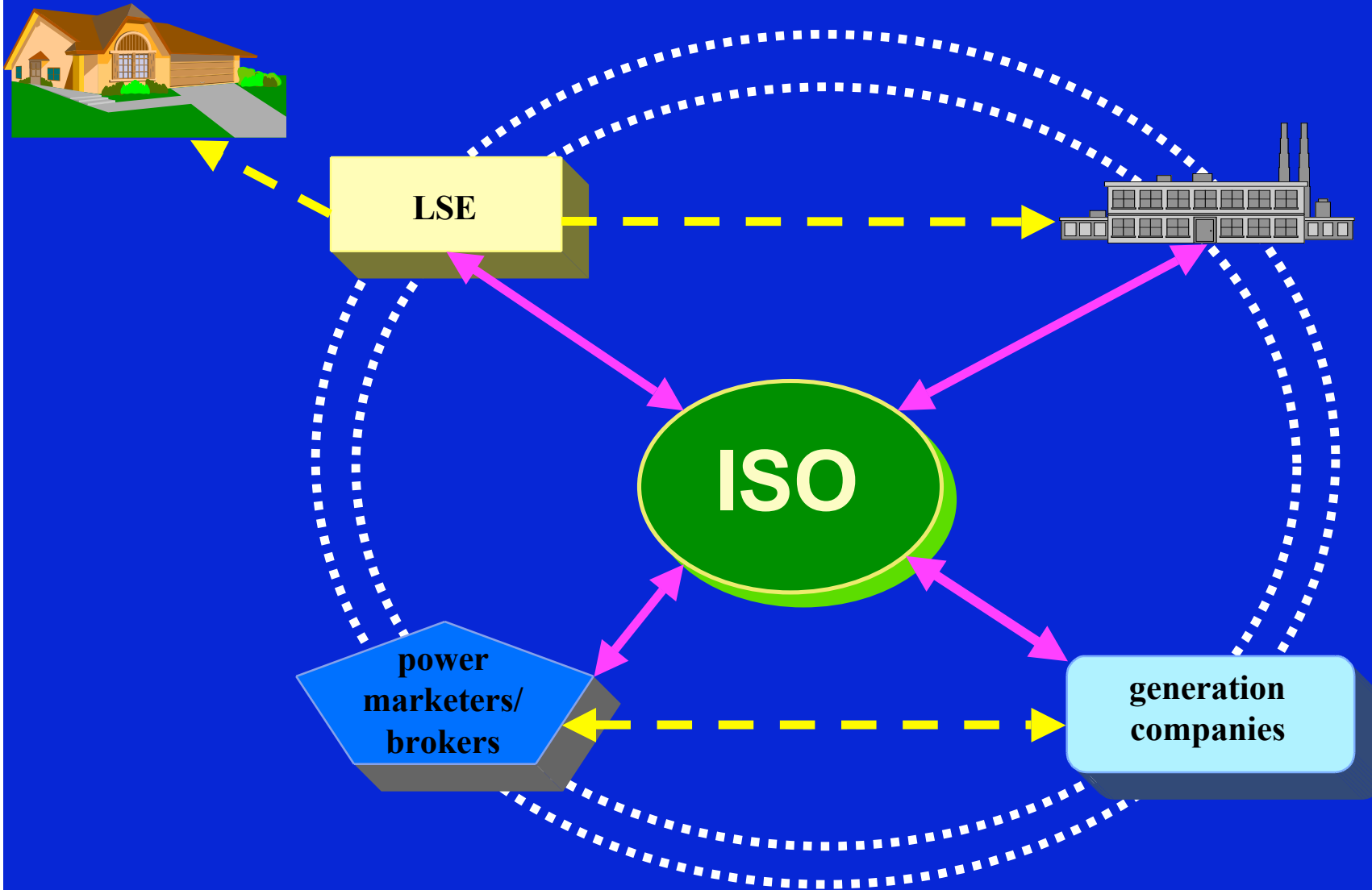


THE TRANSMISSION “COP”

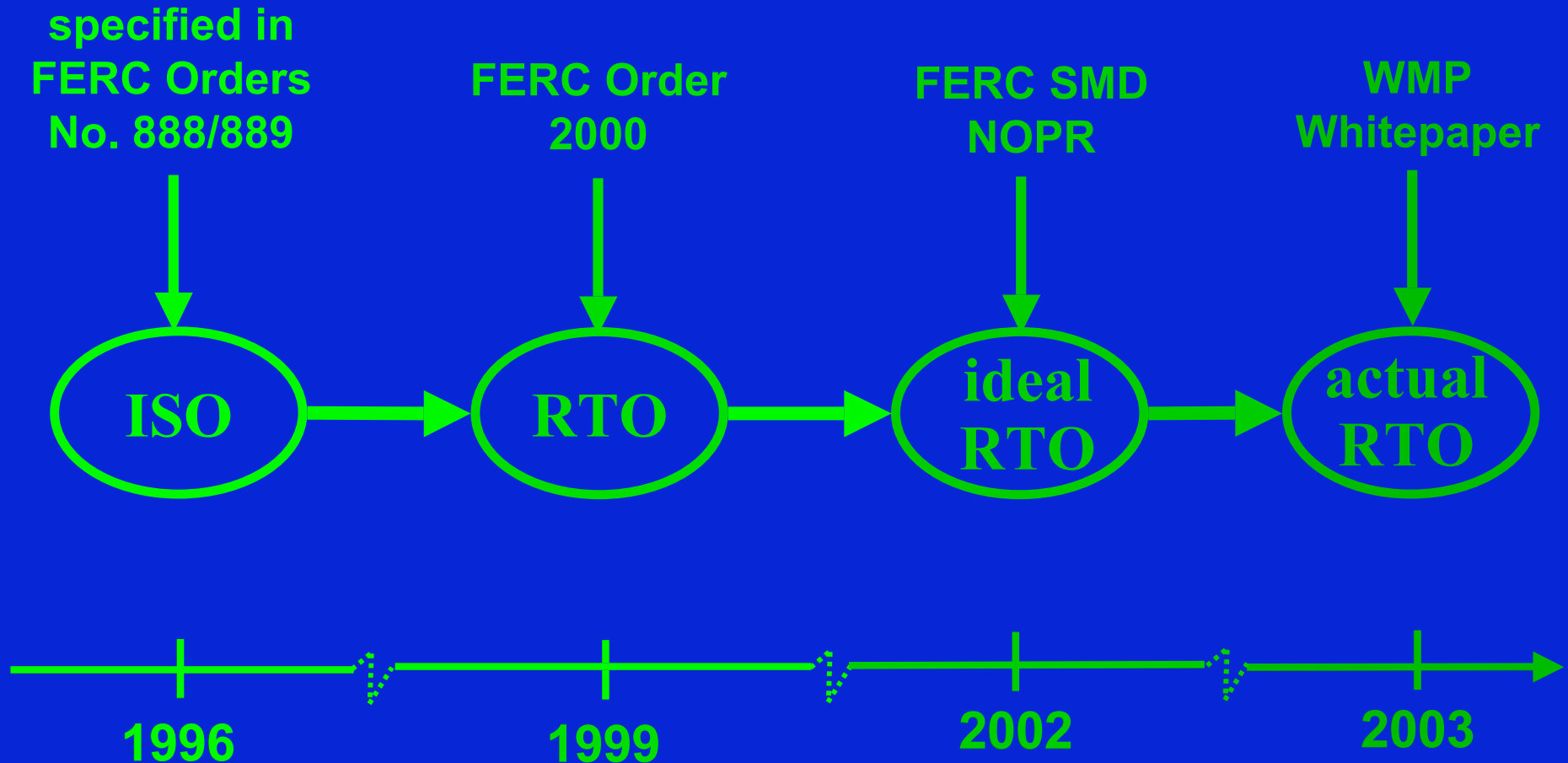
transmission services
markets
system reliability



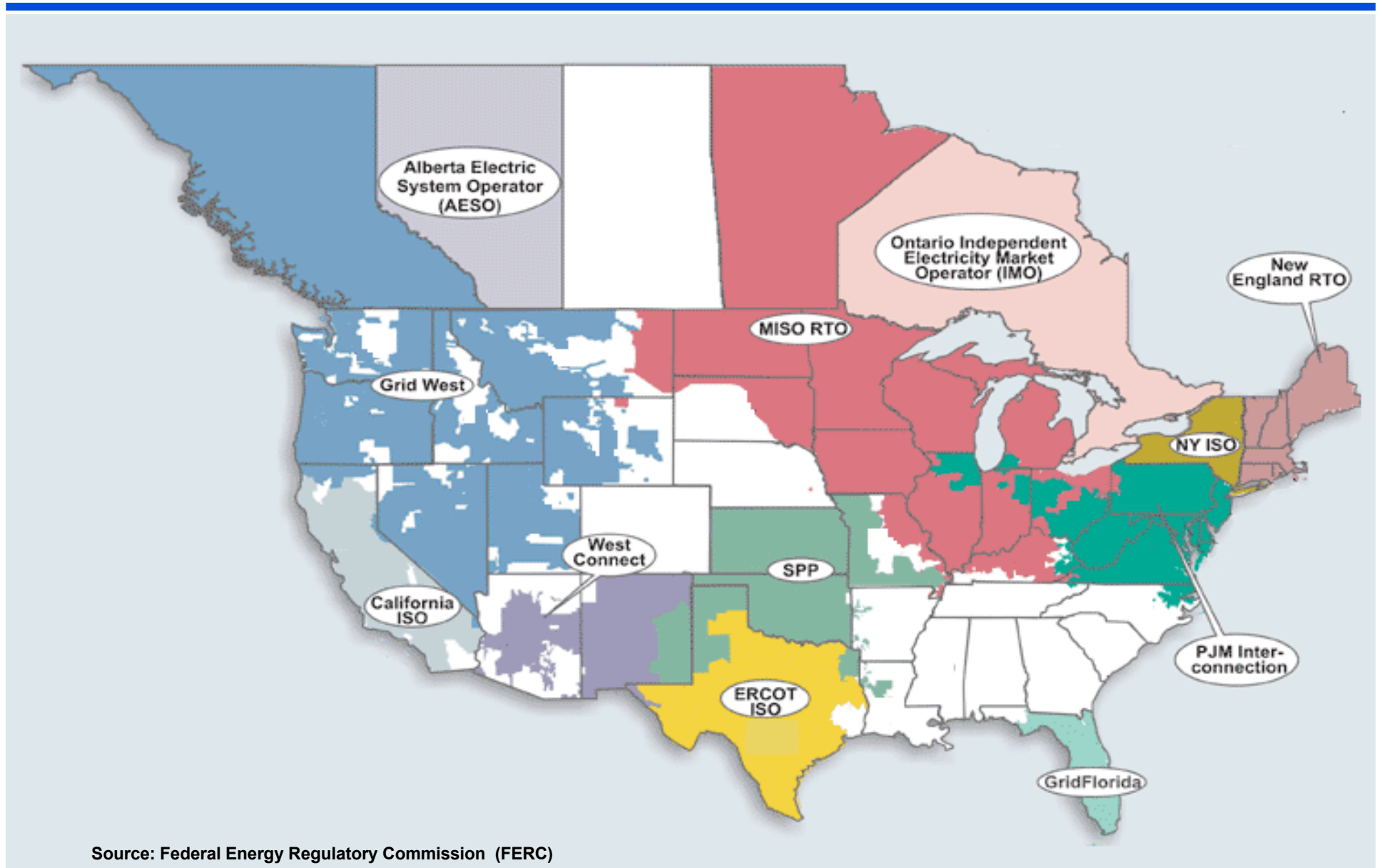
THE ISO AND TRANSMISSION CUSTOMERS



THE EVOLUTION TO RTOs



EXISTING AND PROPOSED RTOs



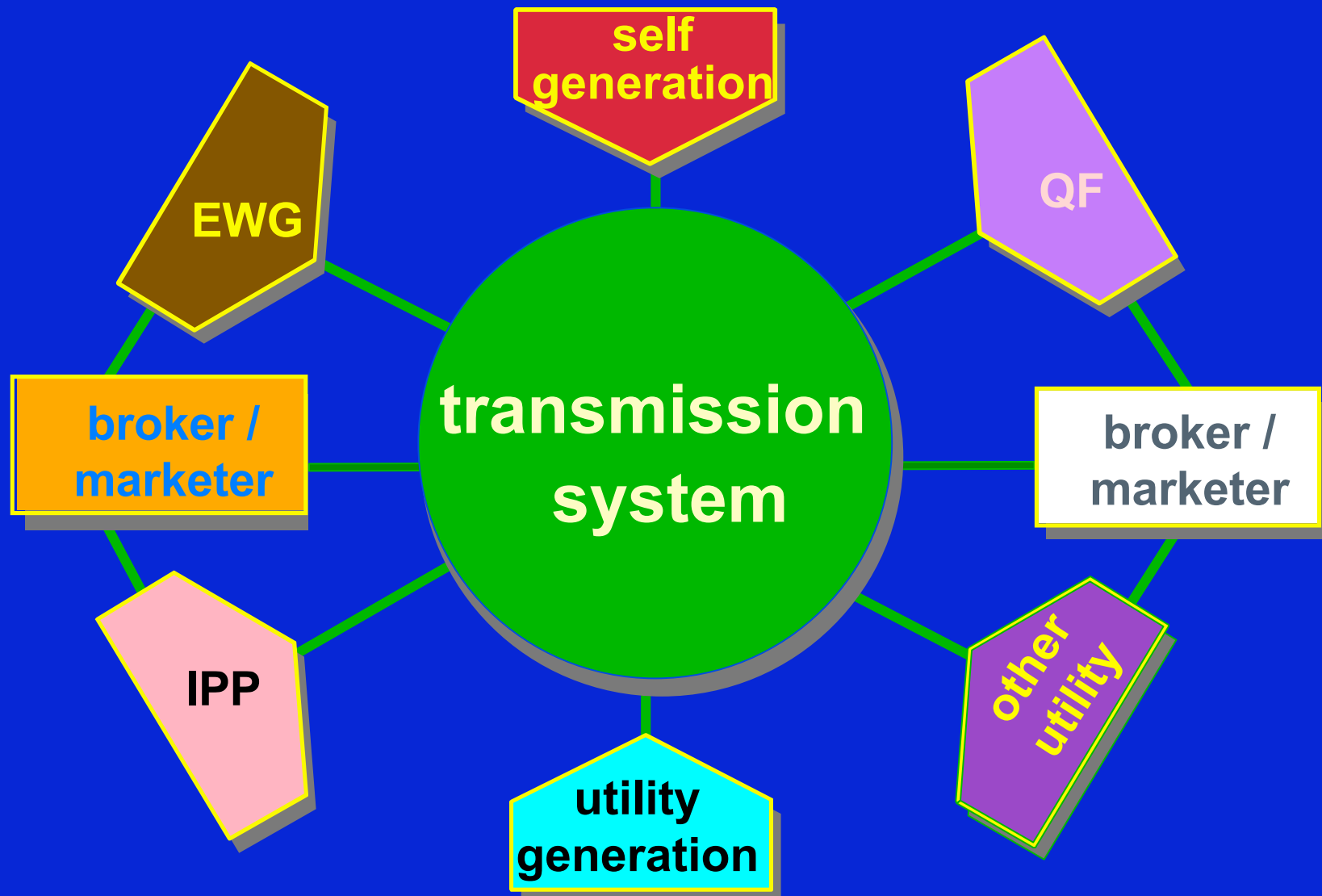
EVOLVING ROLE OF TRANSMISSION SERVICES

- ❑ Transmission systems developed primarily to meet the demands of each utility's *native load customers*
- ❑ Major stages of transmission development :
 - connection of remote generating resources to load centers
 - interconnection of utilities for reliability
 - construction of ties to support inter-utility transactions

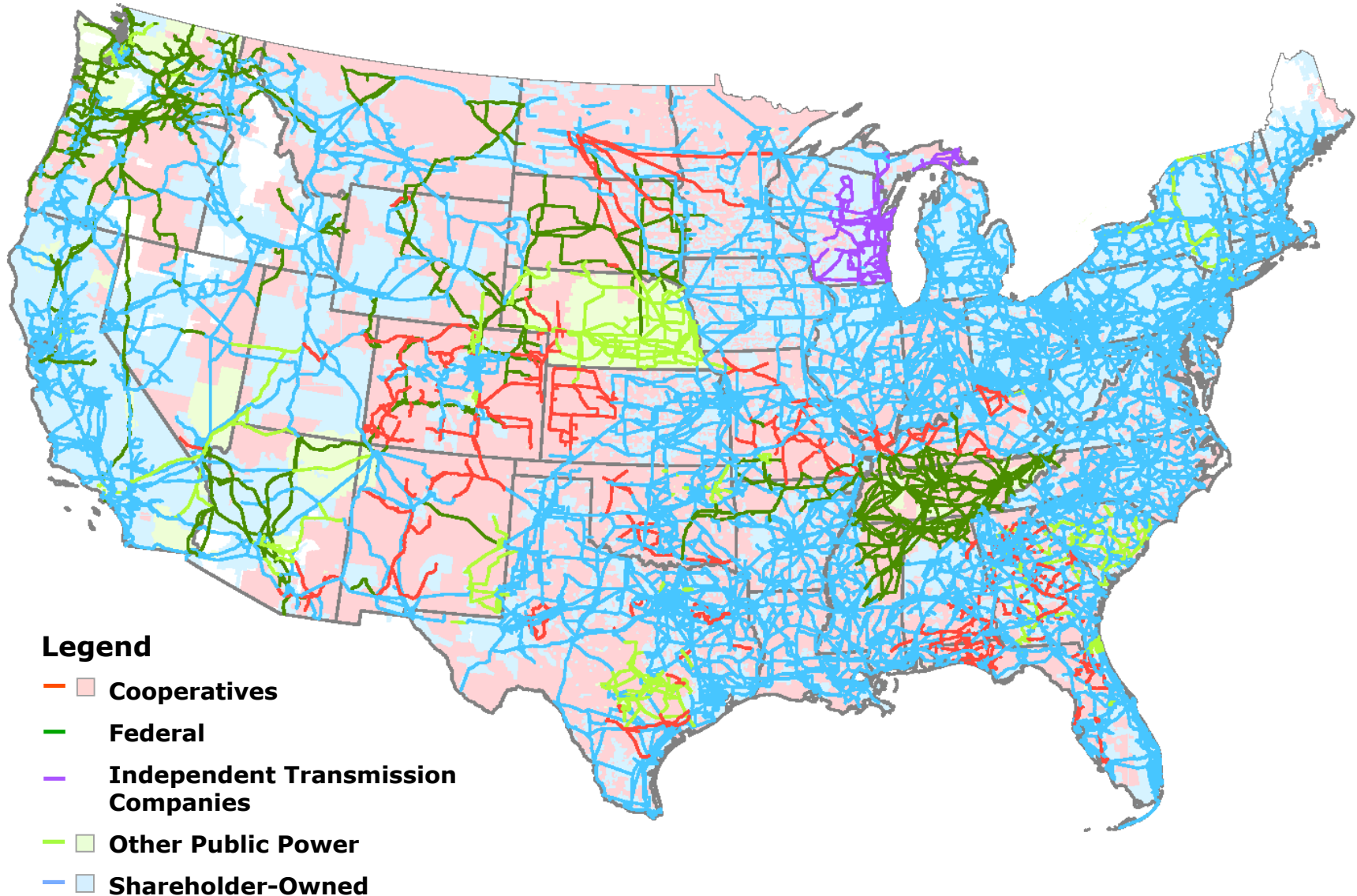
EVOLVING ROLE OF TRANSMISSION SERVICES

- ❑ Transmission owning utilities provided *bundled* transmission and generation services through:
 - full or partial requirements services
 - integration agreements
- ❑ Limited amount of *transmission only* services was provided to
 - embedded transmission dependent utilities
 - embedded qualifying facilities or QFs
- ❑ In the competitive wholesale electricity markets, unbundled transmission service is taking on a *common carrier* role

“COMMON CARRIER” TRANSMISSION SERVICE

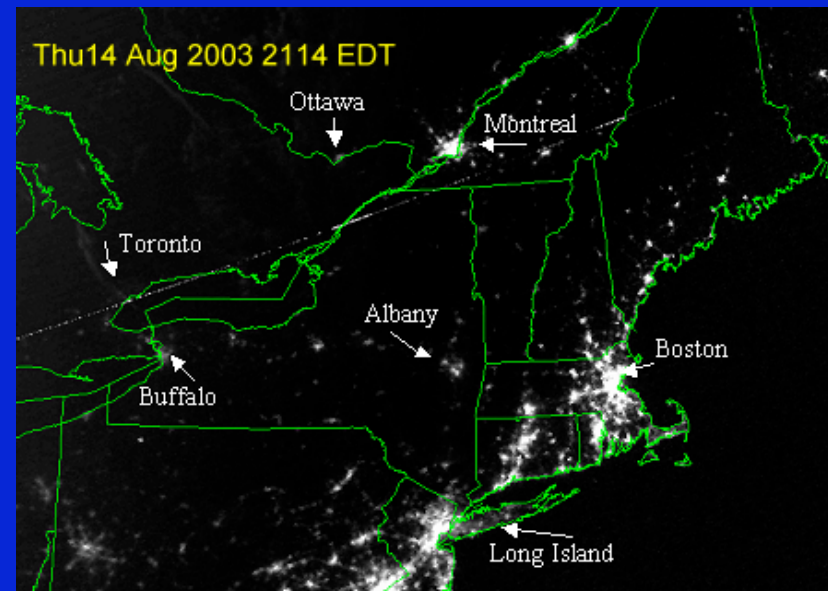
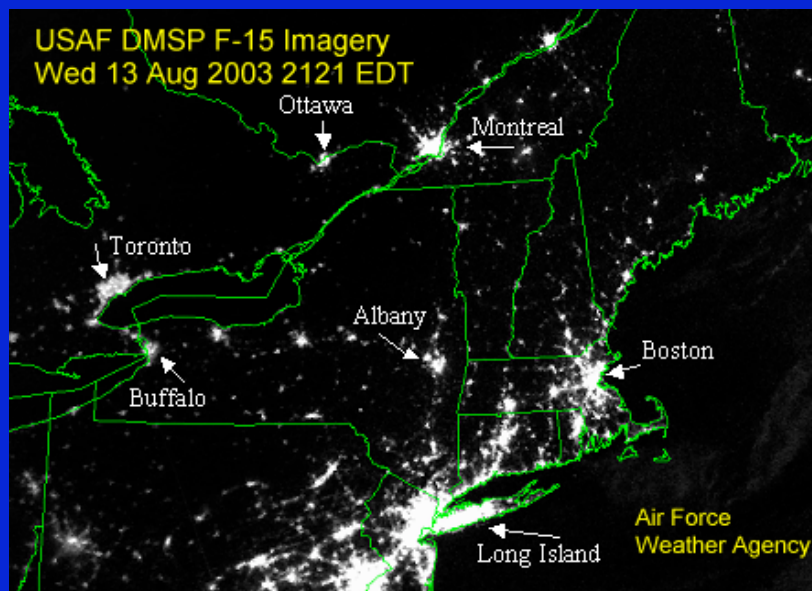


ELECTRIC TRANSMISSION LINES IN THE U.S.



THE 2003 MEGA - BLACKOUT

- ❑ The blackout, whose costs estimates range from **6.5 to 12.9 billion US \$**, exposed the weaknesses of the **North American transmission infrastructure**



THE 2003 MEGA - BLACKOUT

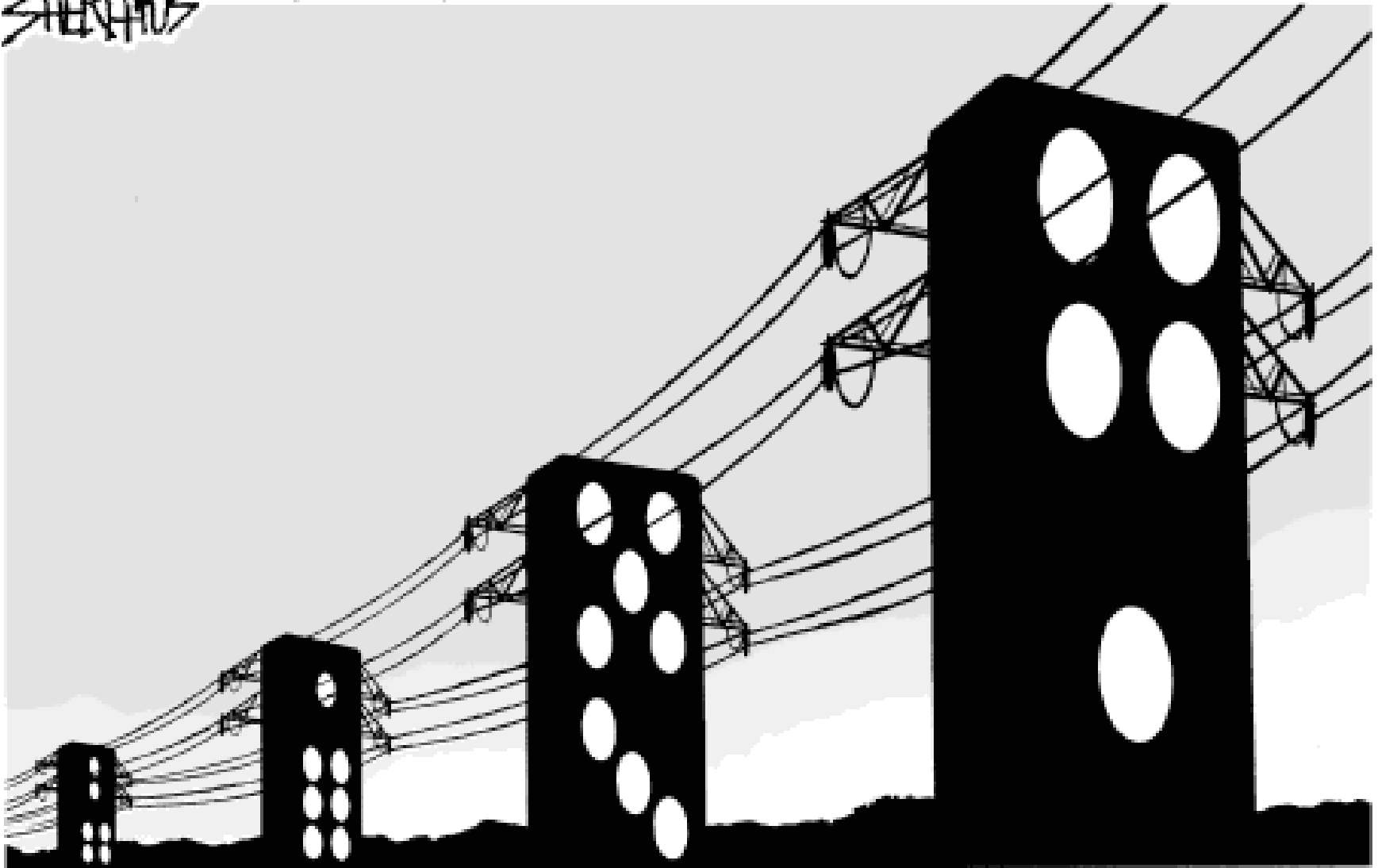
- ❑ Largest single blackout ever in North America
- ❑ Area covering 8 U.S. states and one Canadian province impacted: total population 50 million
- ❑ 61,800 *MW* load lost
- ❑ 34,000 *miles* of transmission and 290 units affected during the cascade of events
- ❑ Five major independent system operators' territories involved

SPECIFIC FACTORS CAUSING THE BLACKOUT

- ❑ “Inadequate *situational awareness*”
- ❑ Failure of timely vegetation management
- ❑ Heavy congestion
- ❑ Cascading outages of lines
- ❑ Cascading outages of generators
- ❑ Unexpected loop flows

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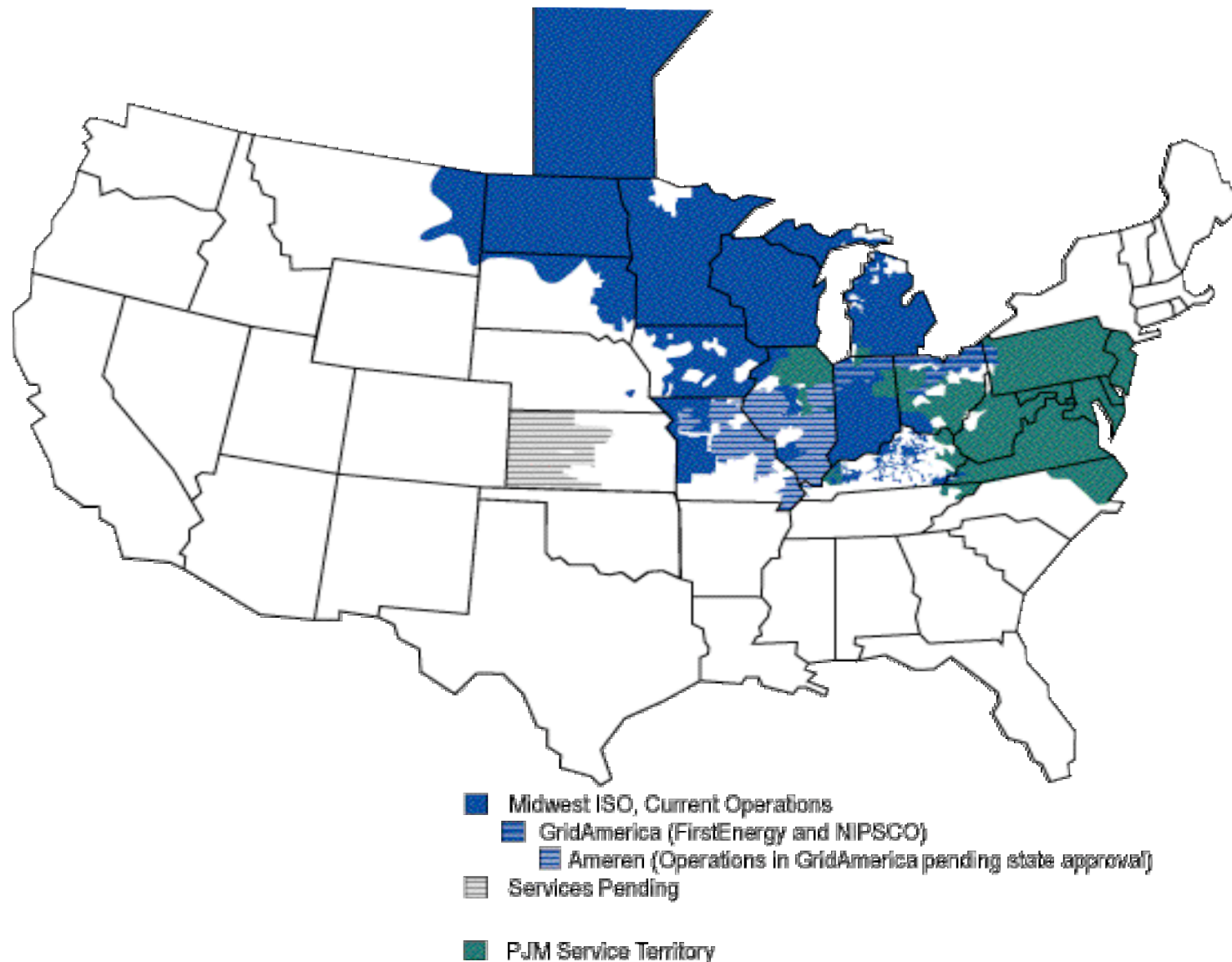


The grid

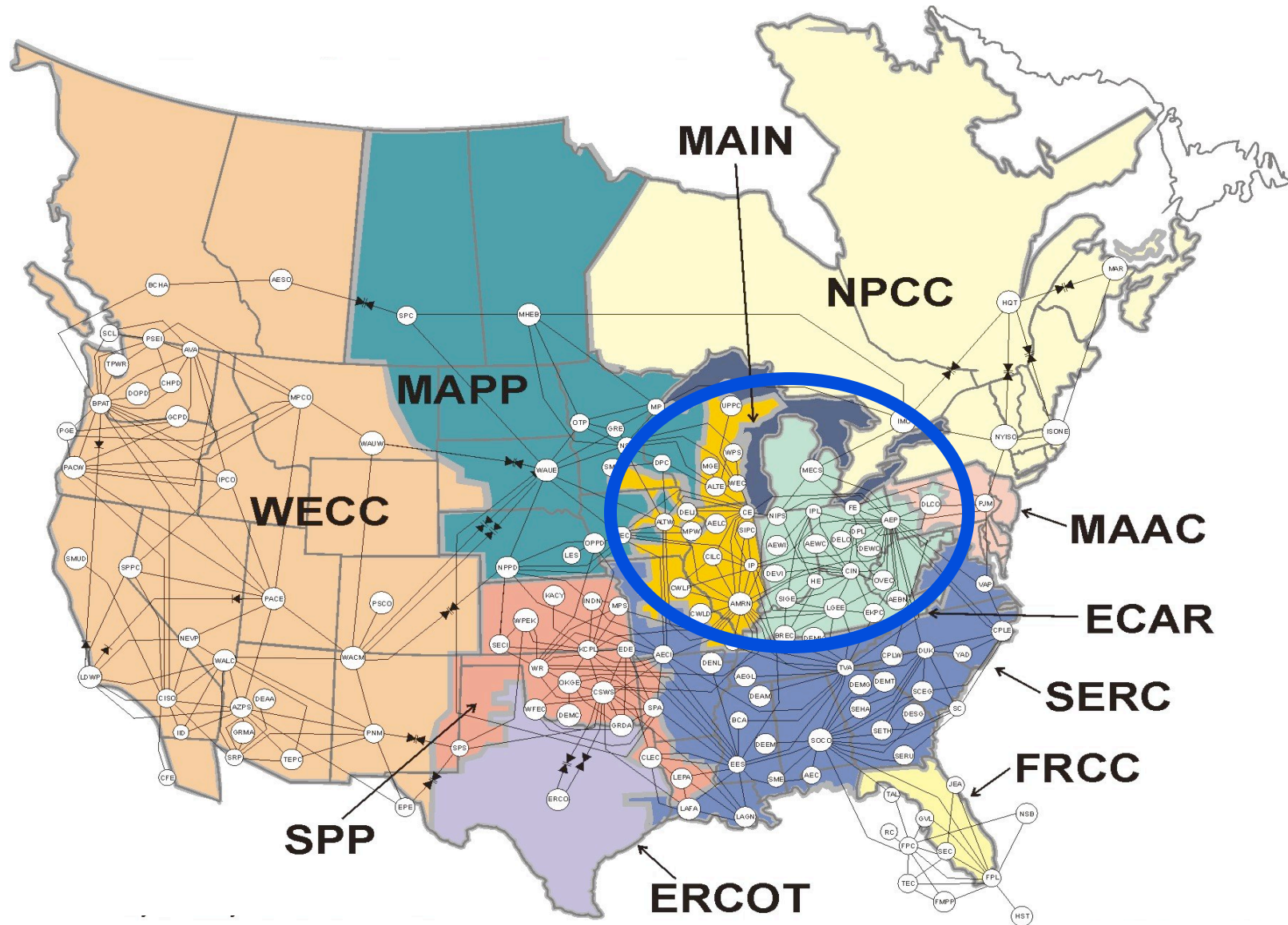
“INADEQUATE SITUATIONAL AWARENESS”

- ☐ **No single entity had a complete picture of what was going on**
- ☐ **Lack of recognition or understanding of the deteriorating conditions in the network**
- ☐ **Lack of procedures to ensure that operators were continually aware of the functional state of their critical monitoring tools**
- ☐ **Inability to be aware of the failure of the IT system**

MISO AND PJM SERVICE TERRITORIES



CONTROL AREAS



ORGANIZATIONAL COMPLEXITIES IN THE MIDWEST

- ❑ 4 reliability councils, 5 ISO's and 6 reliability coordinators were involved in the blackout
- ❑ There are 18 inter-control-area interfaces across the PJM/MISO reliability coordinator boundary
- ❑ MISO's and PJM's lack of information resulted in no effective security control actions to respond to the fast evolving situation

MAJOR PROBLEM : LACK OF REACTIVE POWER

- ❑ Reactive power is critically important in the maintenance of the desired voltage profile throughout the interconnected network
- ❑ As transmission lines get loaded more heavily, they consume increasing amounts of reactive power resulting in insufficient reactive power levels at the load buses
- ❑ Inadequate supply of reactive power results in declining voltages and may, in the limit, lead to voltage collapse

MAJOR PROBLEM : LACK OF REACTIVE POWER



East generator reactive power
limit is 1200 MVar

base case

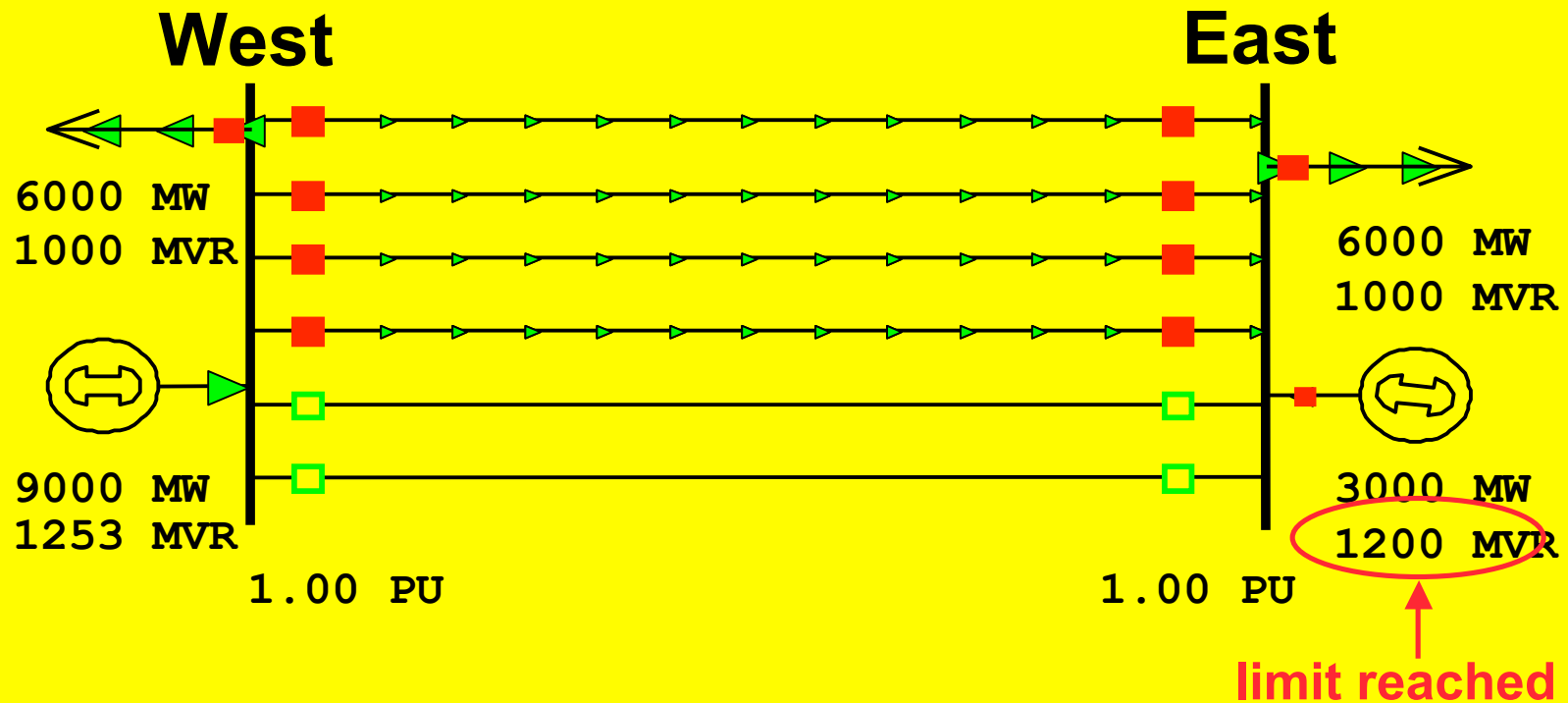
3000 MW transfer – 500 MW per line

MAJOR PROBLEM : LACK OF REACTIVE POWER



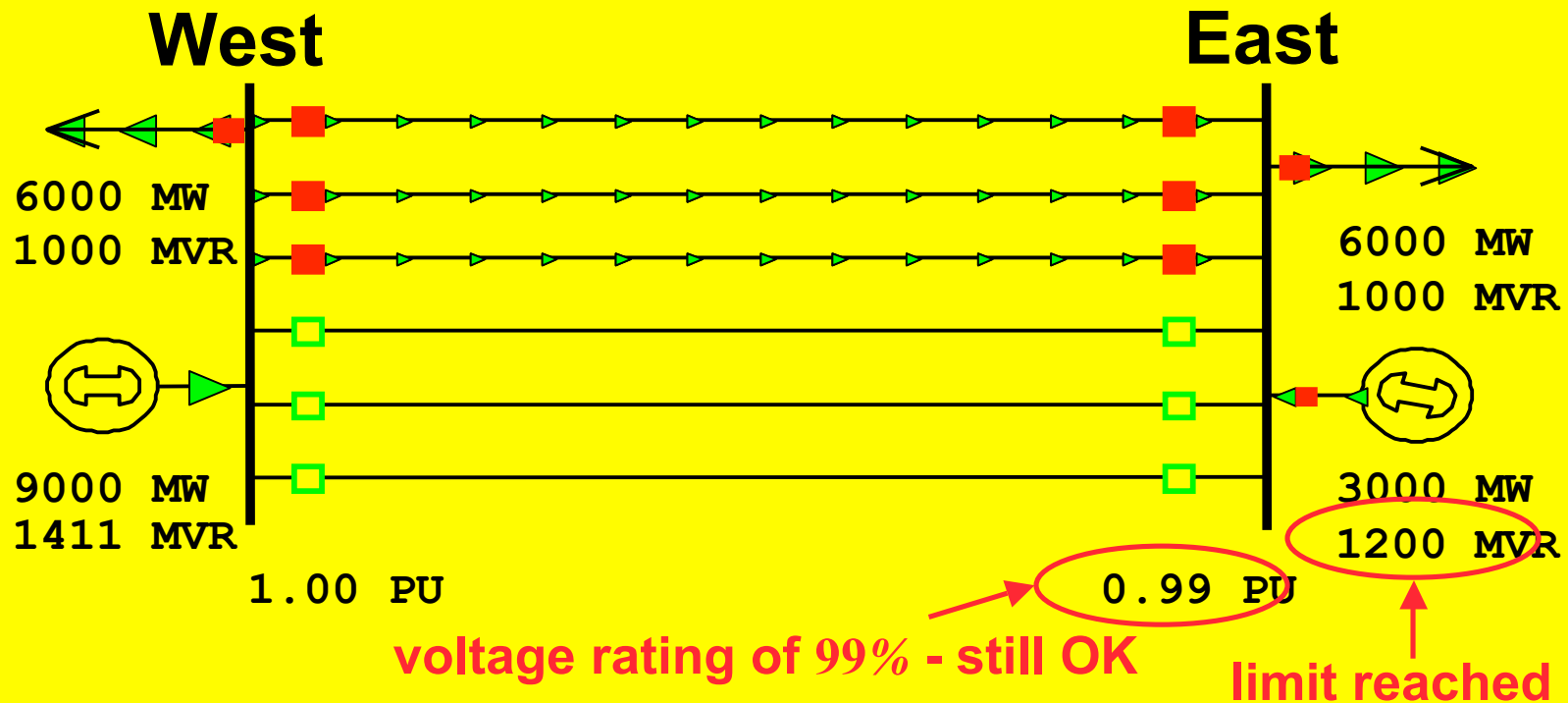
one line out
3000 *MW* transfer – 600 *MW* per line

MAJOR PROBLEM : LACK OF REACTIVE POWER



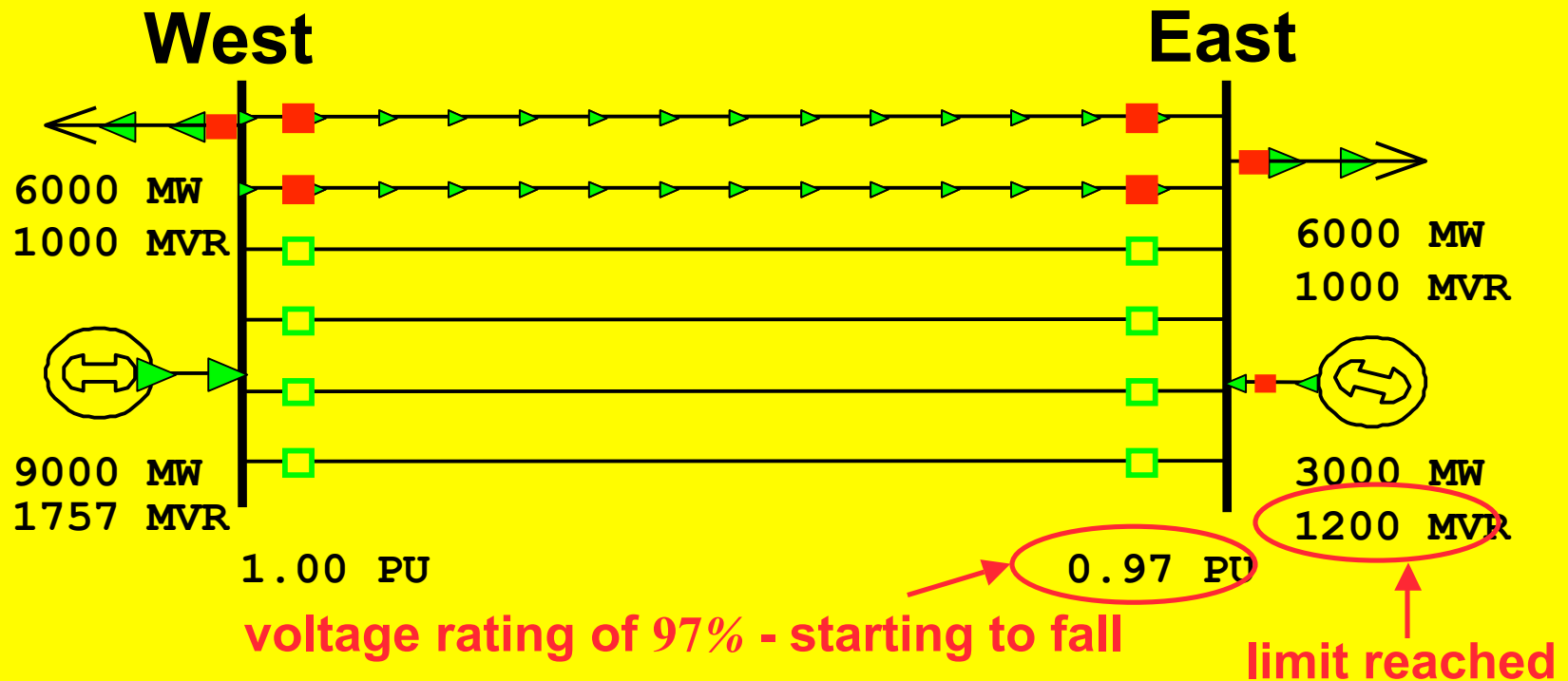
two lines out
3000 MW transfer – 750 MW per line

MAJOR PROBLEM : LACK OF REACTIVE POWER



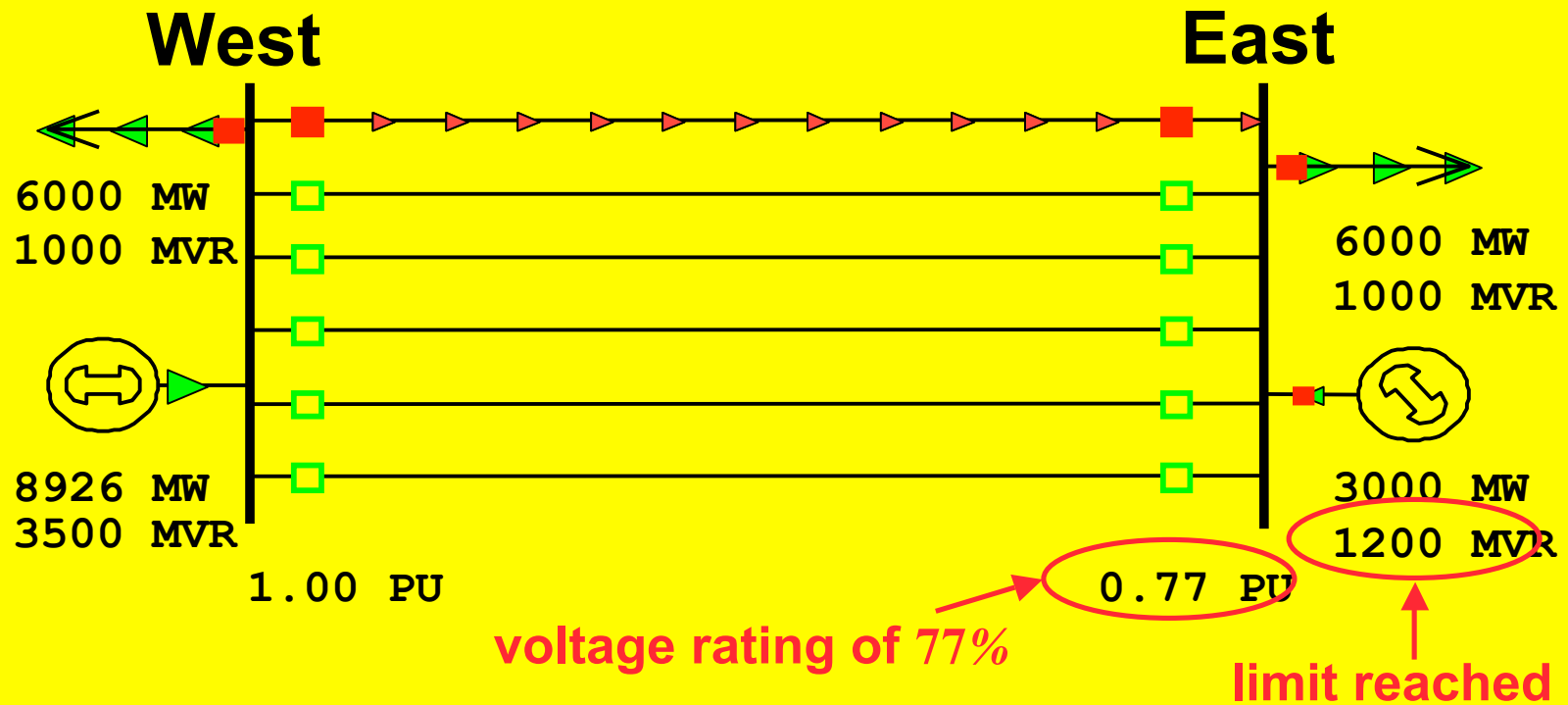
three lines out
3000 MW transfer – 1000 MW per line

MAJOR PROBLEM : LACK OF REACTIVE POWER



four lines out
3000 MW transfer – 1500 MW per line

MAJOR PROBLEM : LACK OF REACTIVE POWER



five lines out
voltage collapse at the East load

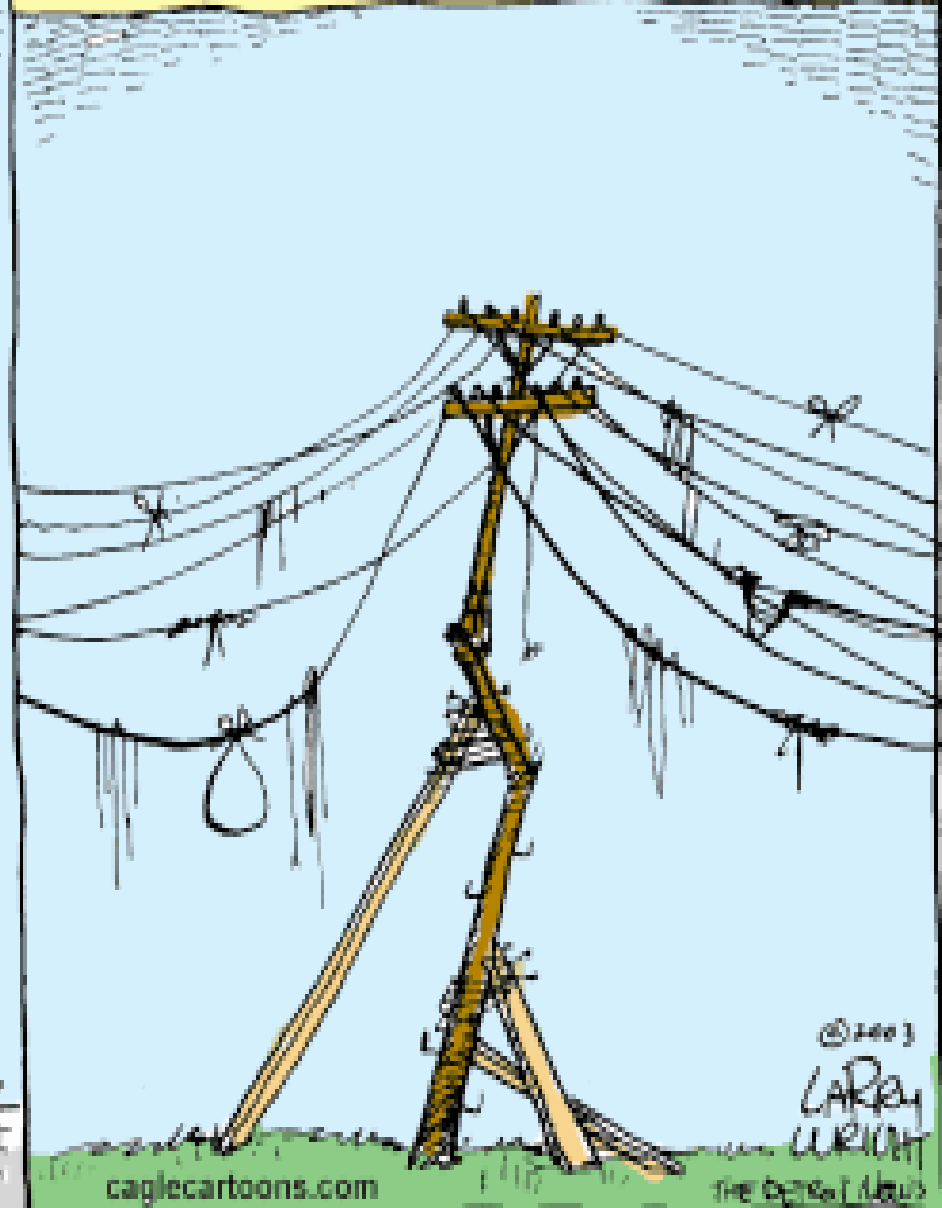
THE BLACKOUT CHALLENGES

- ☐ Modernization of transmission grid
- ☐ Change of protection philosophy including
proper coordination of relay devices in an
interconnected system
- ☐ Training of control center operators

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KEY RECOMMENDATIONS FROM THE BLACKOUT INVESTIGATION

- ☐ **Strengthen the institutional framework for reliability management in North America**
- ☐ **Integrate a “reliability impact” consideration into the regulatory decision-making process**
- ☐ **Strengthen reactive power and voltage control practices in all NERC regions**
- ☐ **Assess IT risk and vulnerability at scheduled intervals**