

THE *NEW* TRANSMISSION BUSINESS

- ❑ Customer choice: “instantaneous” changing of suppliers and buyers
- ❑ Vertical unbundling and horizontal consolidation
- ❑ Increasing volumes in interregional energy transfers
- ❑ Proliferation in the number of transactions
- ❑ Independent grid operators without supply and demand resources
- ❑ Decentralized decision making

UNBUNDLING IMPACTS ON OPERATIONS

- ❑ More frequent changes in system conditions and flows
 - ❑ More volatile pattern of generator commitment
 - ❑ Unpredictable and more frequently varying structure/configuration
 - ❑ Greater variability in controllers
 - ❑ Market price variability
- increased system volatility

TRANSMISSION CHALLENGES

- ❑ **Data availability and management**
- ❑ **Real-time operations**
 - **real-time security monitoring and control**
 - **analytical and software tools enhancement**
- ❑ **Effective congestion management**
- ❑ **Regional transmission planning and expansion**
 - **transmission investment incentives**
 - **seams issues**

UNDERLYING CHALLENGES: DATA AVAILABILITY AND MANAGEMENT

- ❑ Two principal aspects:
 - effective data acquisition and storage
 - *data overwhelm* problem: the effective management of the increasing volumes of data
- ❑ Availability of data is critical due to the potential for conflicts between physical and market data
- ❑ Effective schemes for data storage, extraction, compression, and visualization are daunting challenges

THE *DATA OVERWHELM* PROBLEM

- ❑ The marked increase in the total number of players**
- ❑ The increasing role of markets**
- ❑ The proliferation in the number of transactions**
- ❑ The impacts of increased volatility in the system**
- ❑ The larger geographic extent of the RTO region**
- ❑ Effective implementation of advances in computing and communications**

CONTROL UNDER UNBUNDLING

- ❑ The principal role of power system control is to maintain system security
- ❑ Under restructuring, the providers of the control actions and the controlling authority are separate and independent entities
- ❑ There is a need to specify effective procedures -- *rules of the road* -- for the acquisition and deployment of control services

CONTROL UNDER UNBUNDLING:

KEY CHALLENGES

- ☐ **Reexamination of control laws**
- ☐ **Integrated control of unbundled generation and transmission**
- ☐ **Maintenance of system security without unduly affecting the market**
- ☐ **Measurement and metering**
- ☐ **Control performance assessment**
- ☐ **Effective harnessing of demand-side participation**

ENHANCEMENT OF ANALYTICAL AND SOFTWARE TOOLS

- ☐ Data visualization
- ☐ Analytical tools for information management, state estimation, voltage security analysis and available transfer capability
- ☐ Software engineering
- ☐ Model development and validation
- ☐ Training simulators

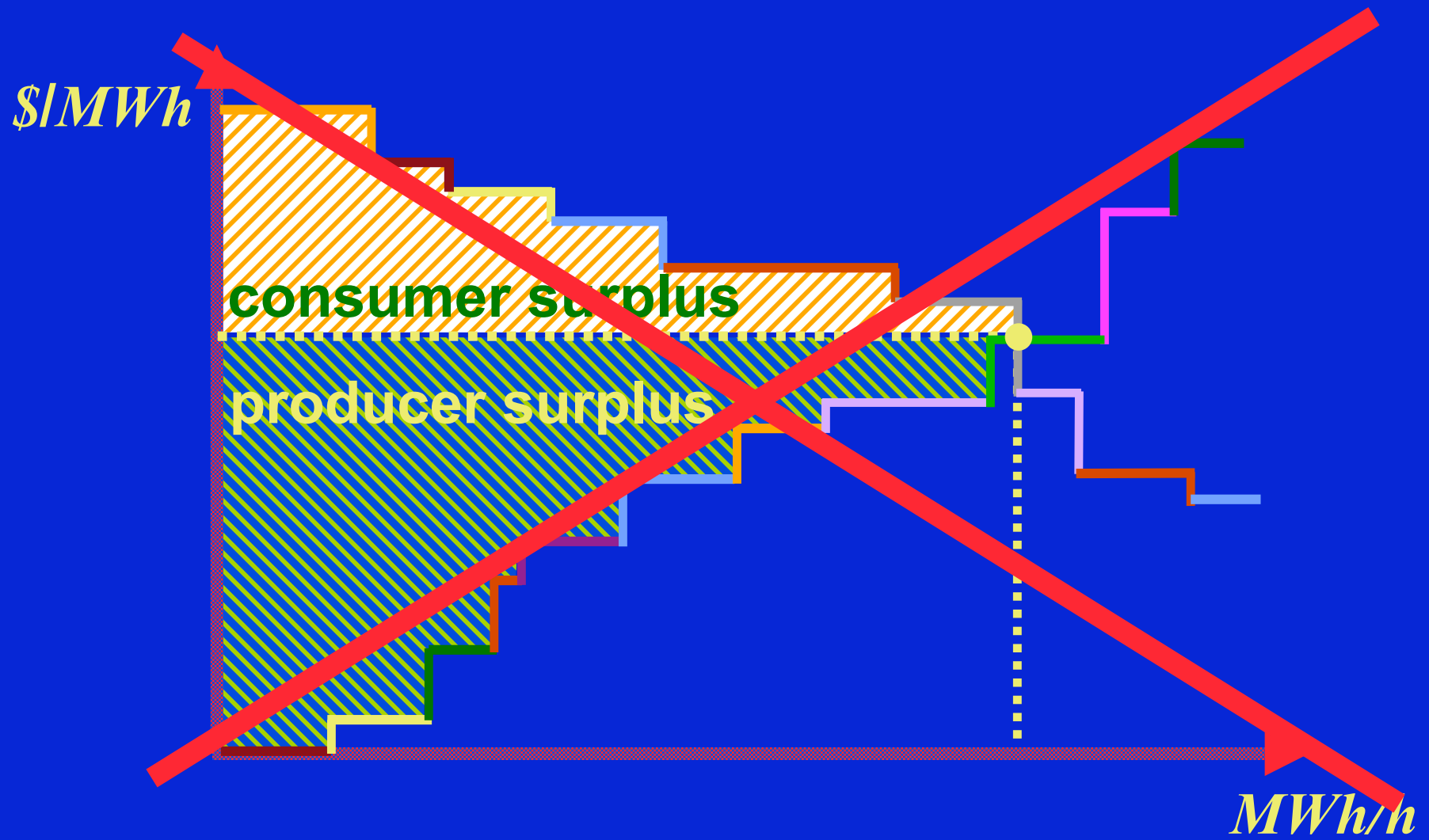
TRANSMISSION CONGESTION



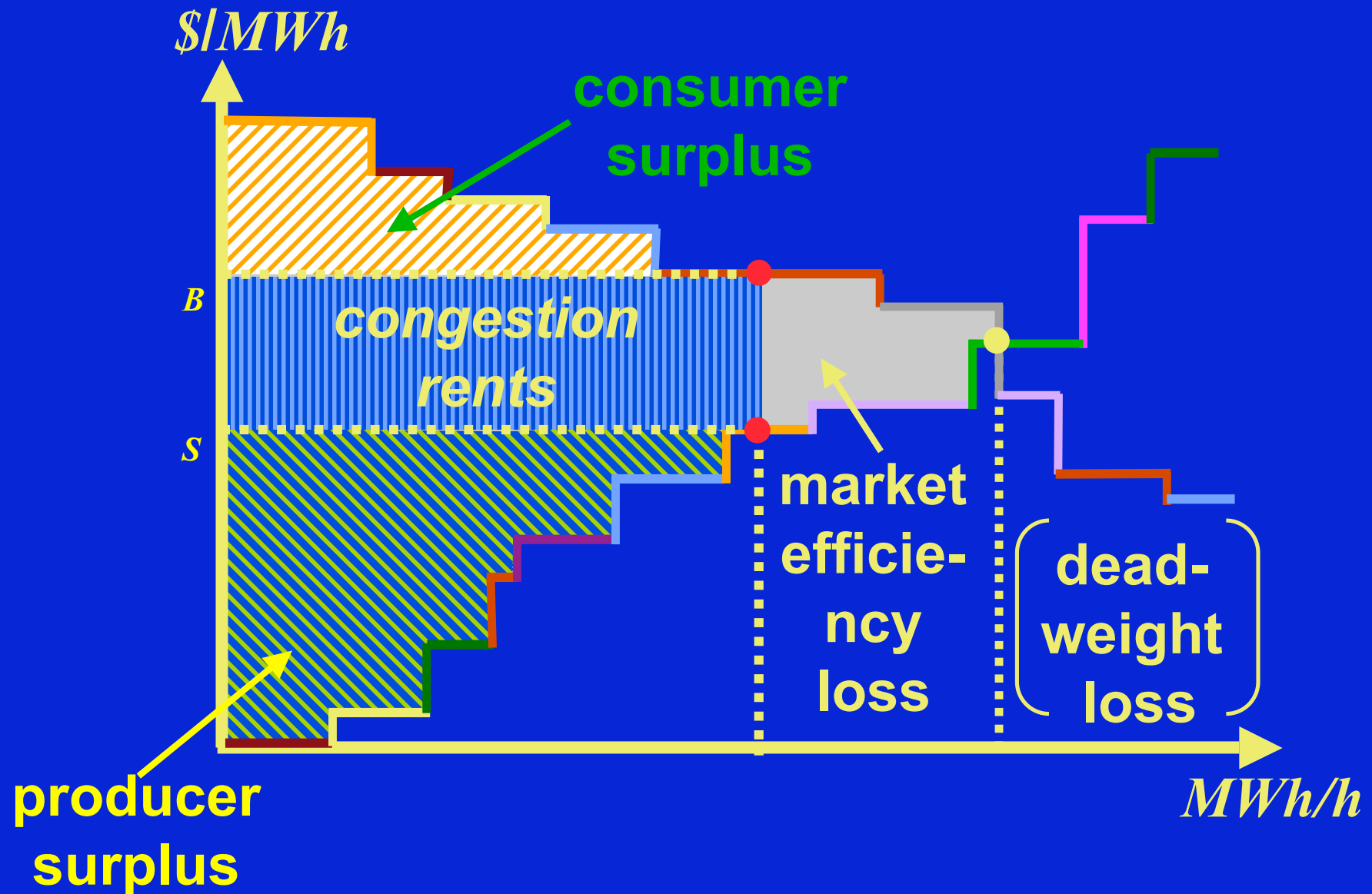
TRANSMISSION CONGESTION

- ❑ Power system reliability considerations require secure operations
- ❑ Congestion occurs whenever the outcome of the transmission unconstrained market requires the provision of transmission services beyond the capability of the transmission network
- ❑ Transmission congestion leads to change in the market equilibrium from that of the transmission unconstrained market; the changes consist of
 - curtailment in generation or load
 - reduction in the social welfare
 - different locational marginal prices (*LMPs*)

SOCIAL WELFARE AND SURPLUSES



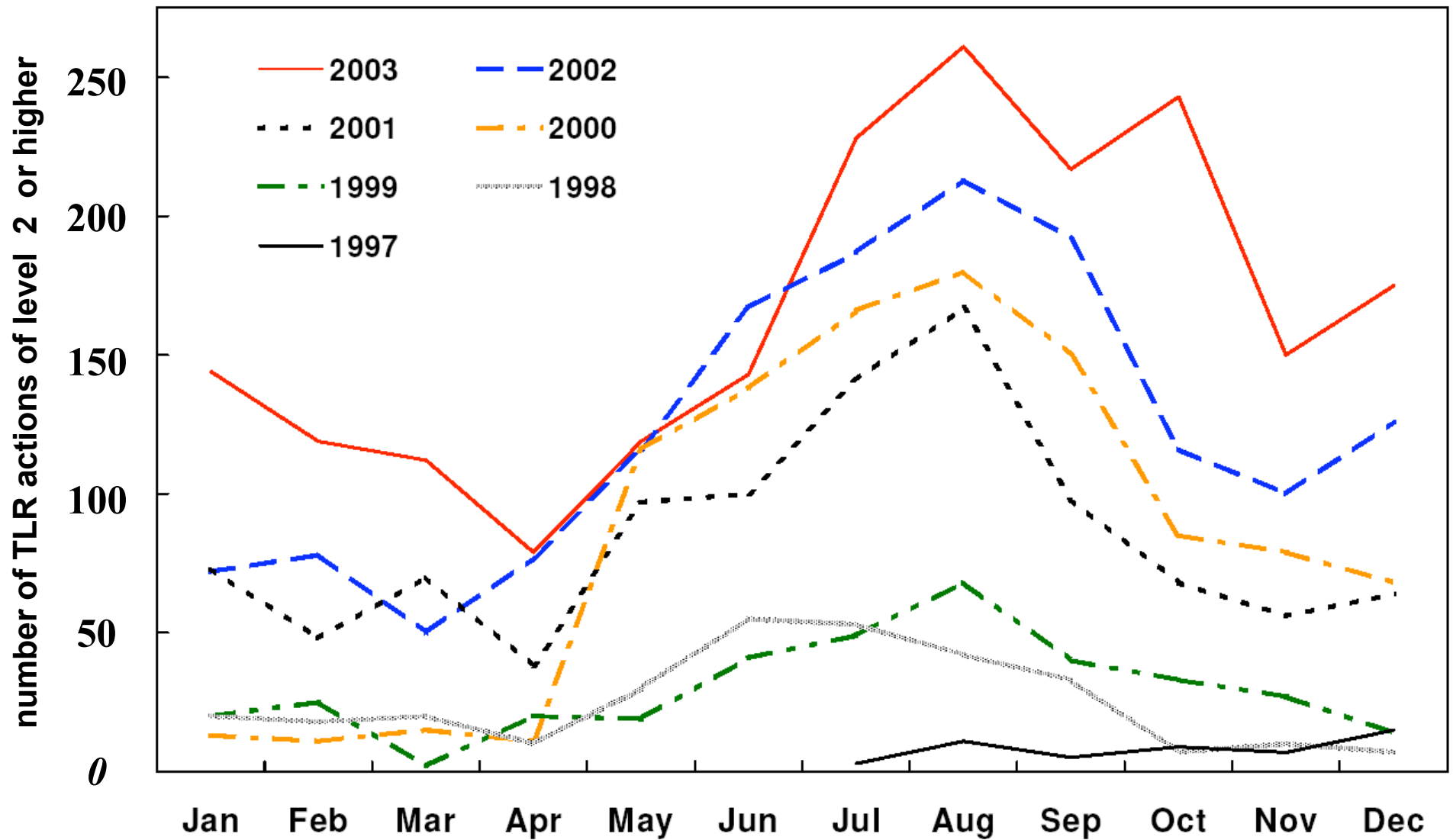
SOCIAL WELFARE AND SURPLUSES



CONGESTION COMPLICATIONS

- ❑ **Multiplicity of entities involved : facility owners, new investors, regulators, IGOs**
 - ❑ **Accommodation of pool and bilateral transactions simultaneously**
 - ❑ **Increasing load demand**
 - ❑ **Decreasing reliability level**
 - ❑ **Low level of investment**
- impose increased stress on the transmission system**

TLR REQUESTS OF LEVEL 2 OR HIGHER



Source: North Electric Reliability Council (NERC)

CONGESTION CHALLENGES

- ❑ Translating *LMPs* into long-term investment signals
- ❑ Effective integration of financial hedging instruments: *FTRs* and *flowgate rights*
- ❑ Managing uncertainty in the behavior of market players

TRANSMISSION PLANNING IN THE COMPETITIVE ENVIRONMENT

- ❑ Frequent congestion situations result whenever too many customers compete for transmission services that the grid is capable of providing
- ❑ Despite the more intense utilization of the grid by the many established and new players, developments in transmission planning have failed to keep pace with the increasing demand

MAJOR SHIFT IN THE PLANNING PARADIGM

- ☐ Cessation of the centralized integrated planning of the past
- ☐ Role of regional planning under the regional transmission organization (RTO)
- ☐ Unclear responsibility for implementation under the separation of ownership and control
- ☐ Role of decentralized decision making

MAJOR SHIFT IN THE PLANNING PARADIGM

- ❑ Planning, to the extent it is performed in the new environment, is an asset management problem
 - critical importance of effective risk management
 - uncertainty in the collection of revenues by investors
 - regulations in a continuous state of flux
 - investment under uncertainty

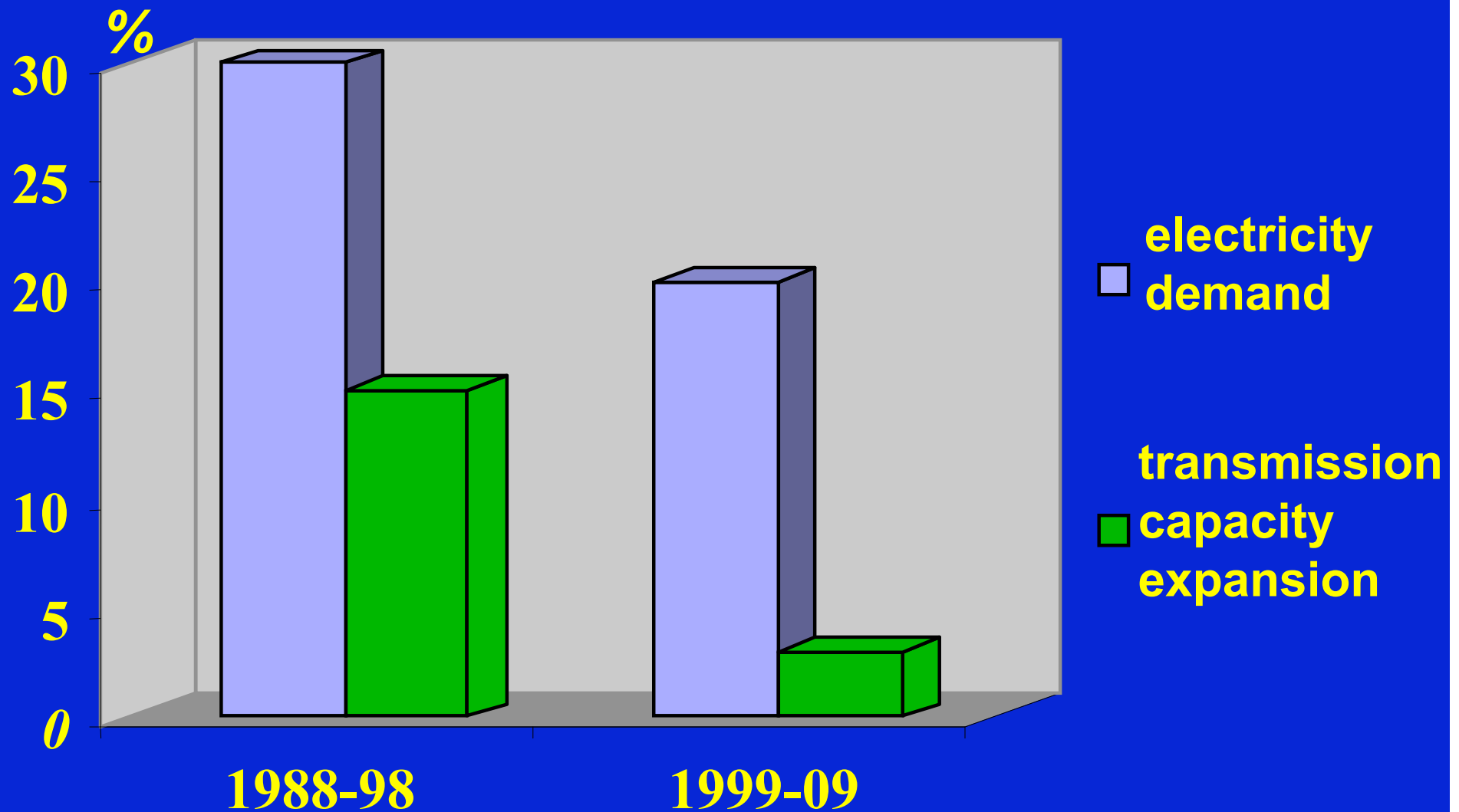
TRANSMISSION EXPANSION

- ❑ Network expansion is by its very nature a very complex multi-period and multi-objective optimization problem
- ❑ Its nonlinear nature and the inherent uncertainty of future developments constitute major complications

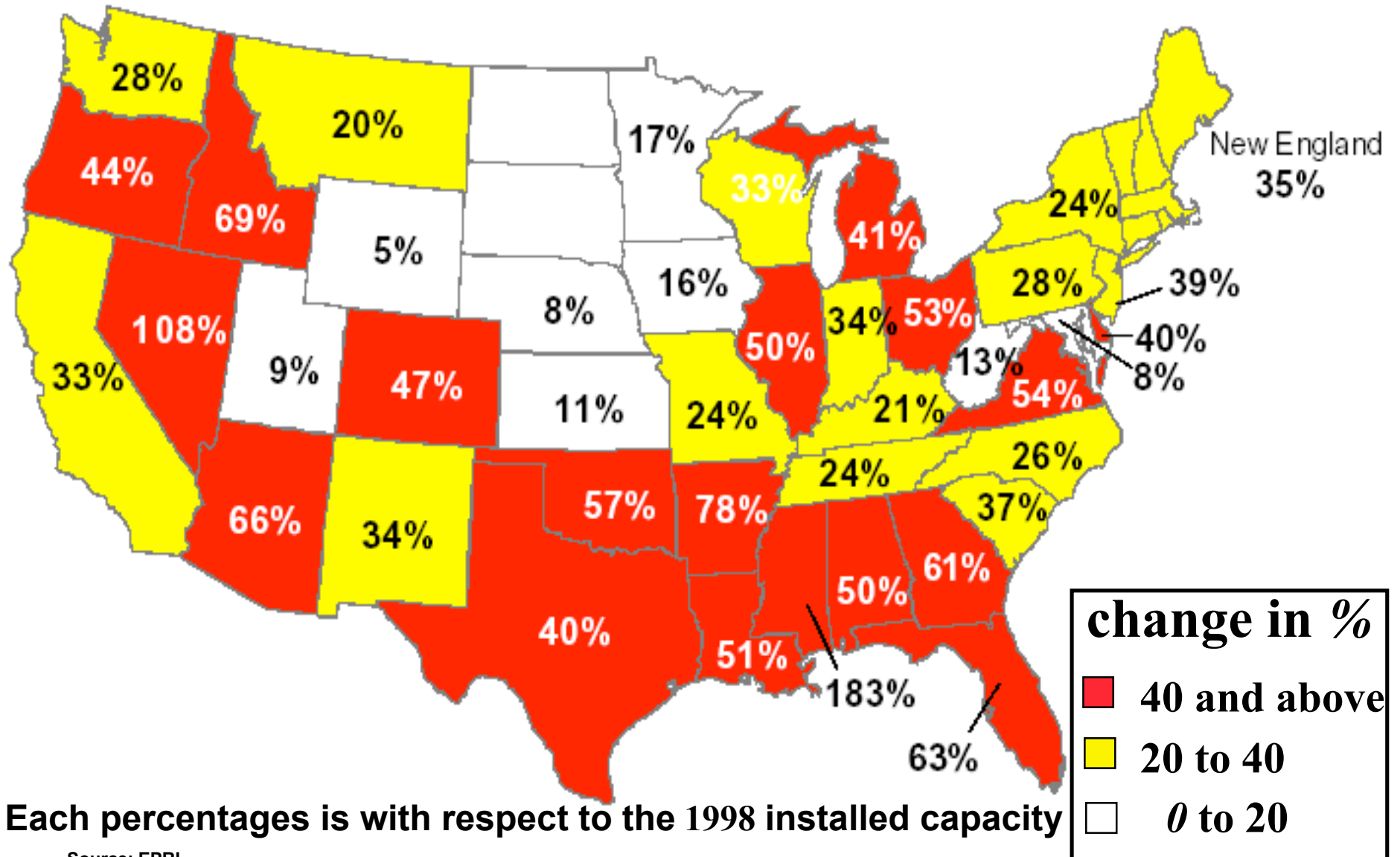
BARRIERS TO TRANSMISSION INVESTMENT

- ☐ Transmission is a regulated service: tariffs are cost based and not value based
- ☐ Lumpiness of transmission expansions
- ☐ Long-term revenue stream needs
- ☐ Free rider problem
- ☐ The lack of clarity in regulatory pricing policy
- ☐ Organizational complexities

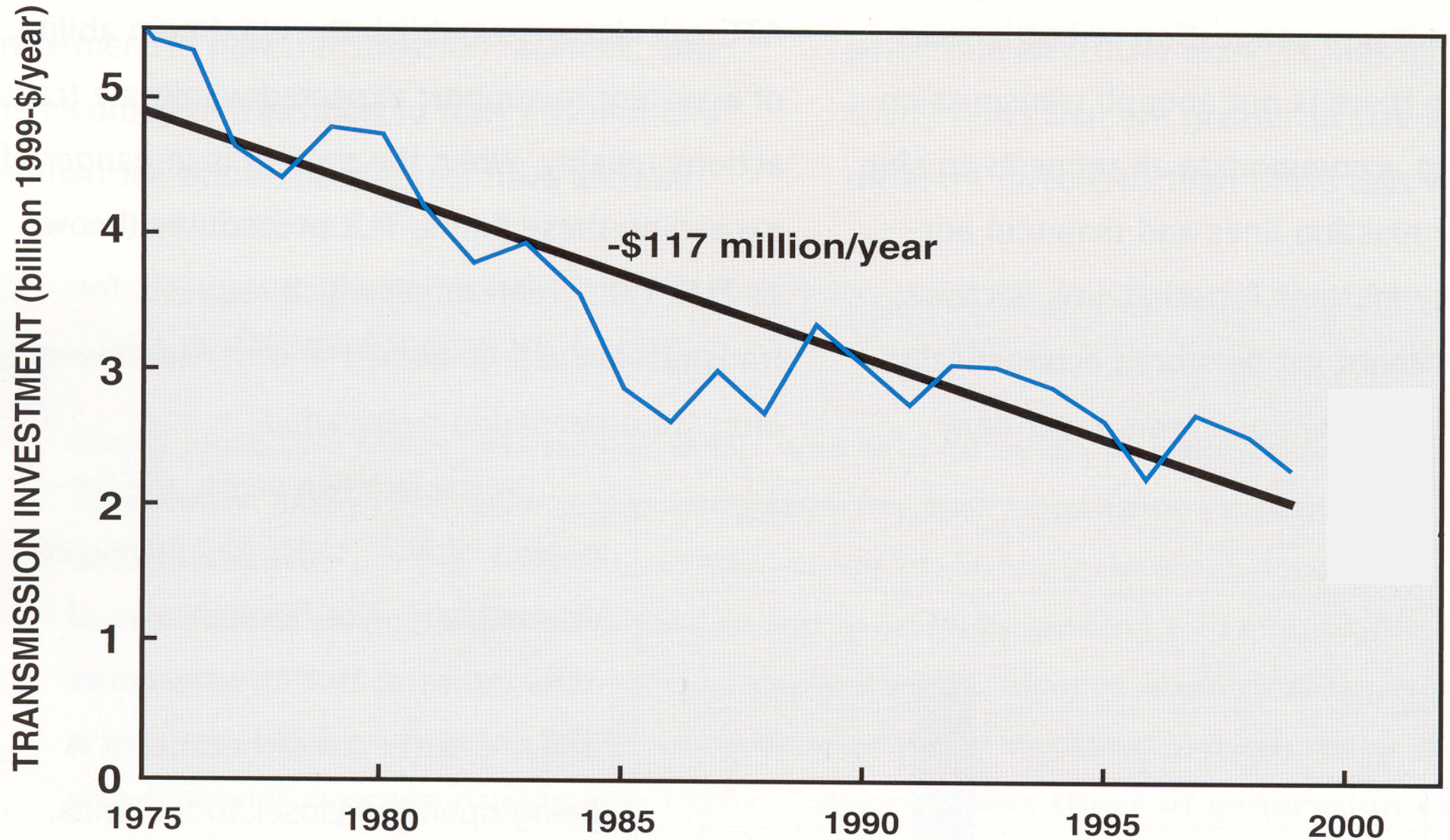
DEMAND AND TRANSMISSION CAPACITY GROWTH



PROJECTED GENERATION GROWTH IN 1998 – 2007

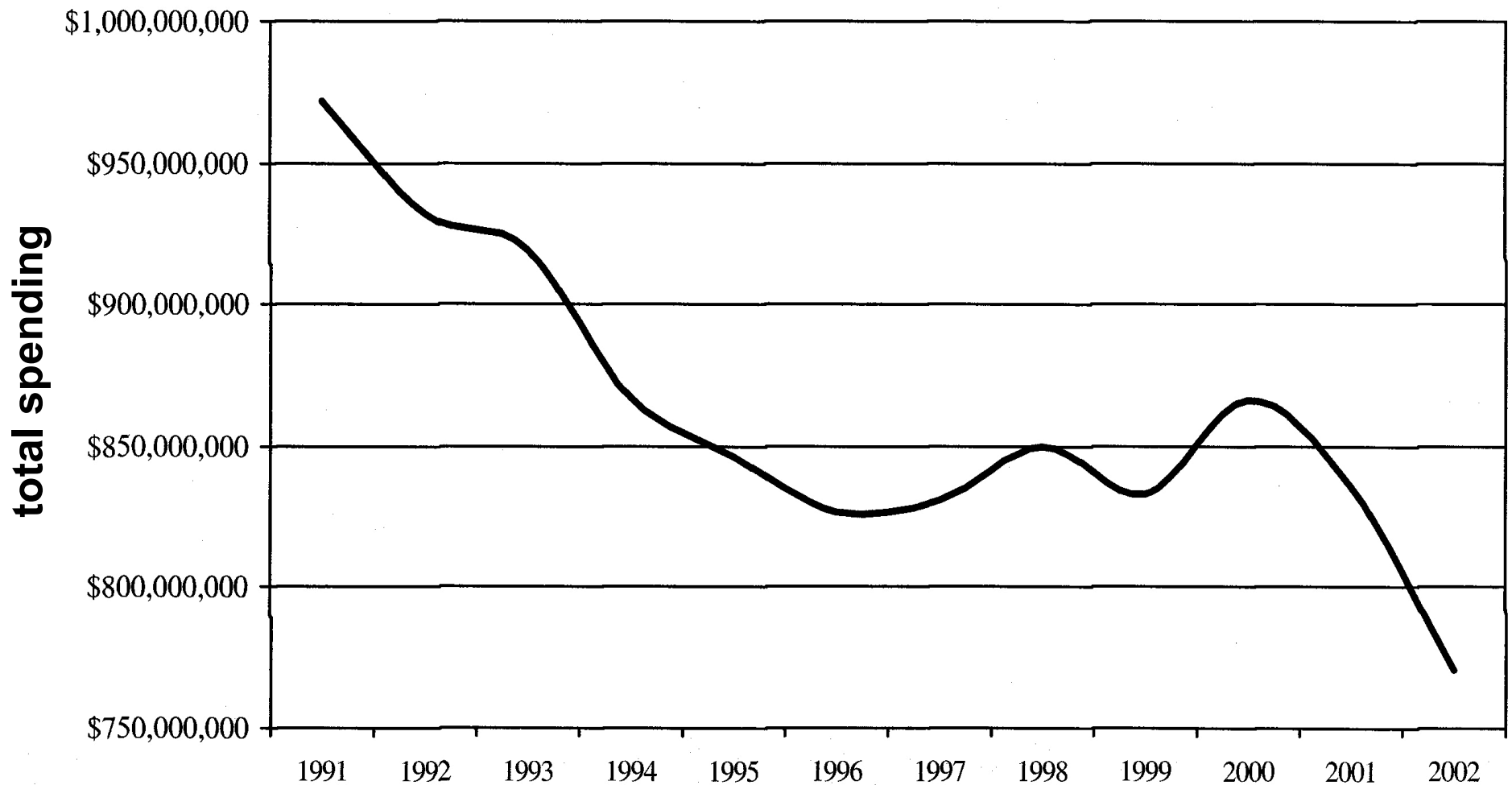


HISTORICAL TRANSMISSION SYSTEM INVESTMENT



Source: E. Hirst, "U.S. Transmission Capacity: Present Status and Future Prospects," June 2004

TRANSMISSION MAINTENANCE SPENDING



Source: FERC Form 1 aggregate data (RDI/Platts); adjusted for inflation using Bureau of Labor Statistics Consumer Price Index

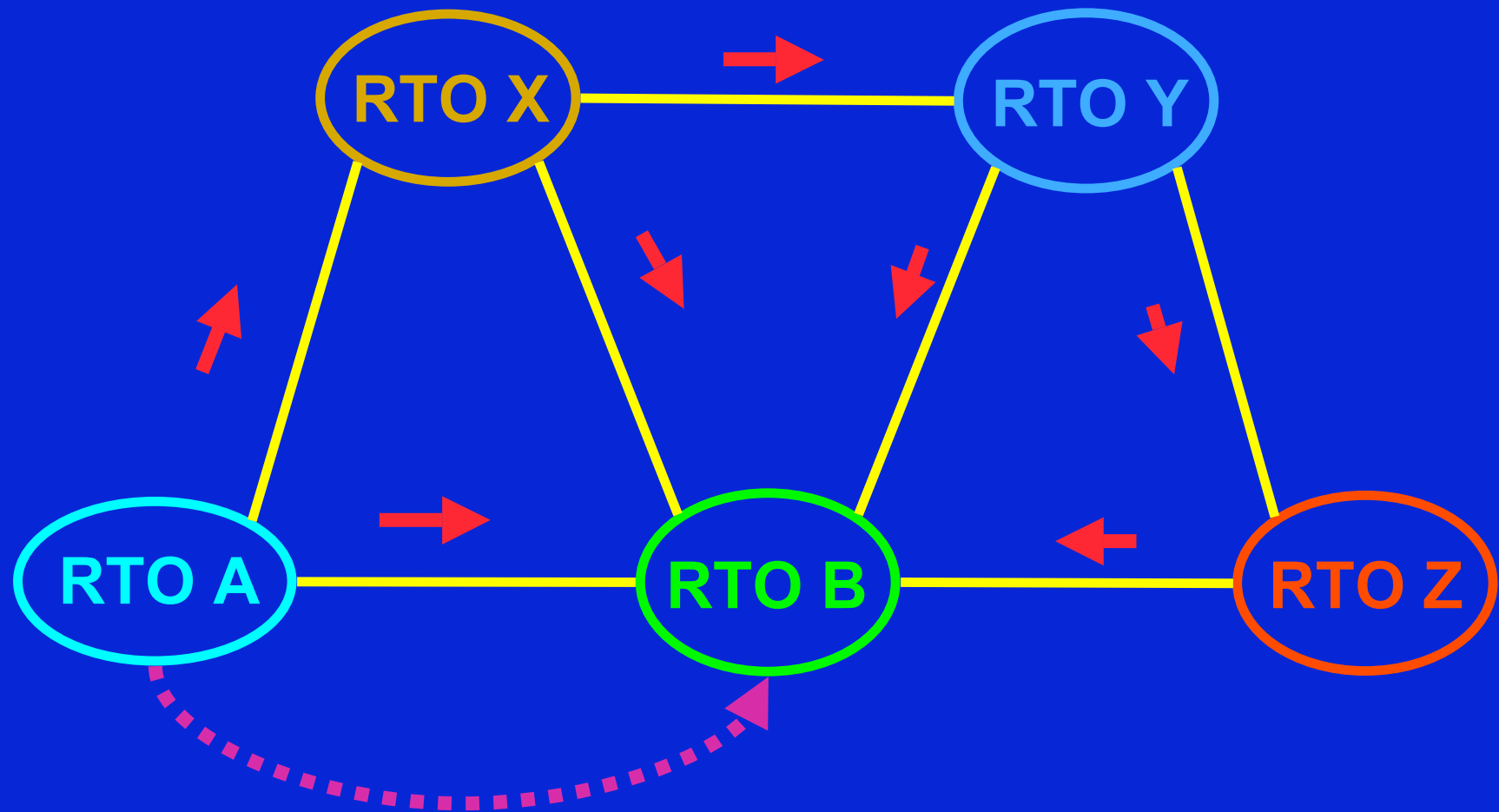
CHALLENGES IN THE EXPANSION OF THE TRANSMISSION SYSTEM

- ❑ Formulation of effective incentives for transmission investment
- ❑ Transmission service pricing on a value rather than cost basis
- ❑ Effectively utilizing advances in technology and IT systems

INVESTMENT NEED IN...

- ❑ **High Temperature Super-Conducting (HTSC) cables, Advanced Composite Conductors (ACC)**
- ❑ **Advanced reactive power compensators**
- ❑ **Dynamic measurement of thermal limits**
- ❑ **Direct System-State Sensors; WAMS**
- ❑ **High-bandwidth communication infrastructure**
- ❑ **On-line security assessment applications**

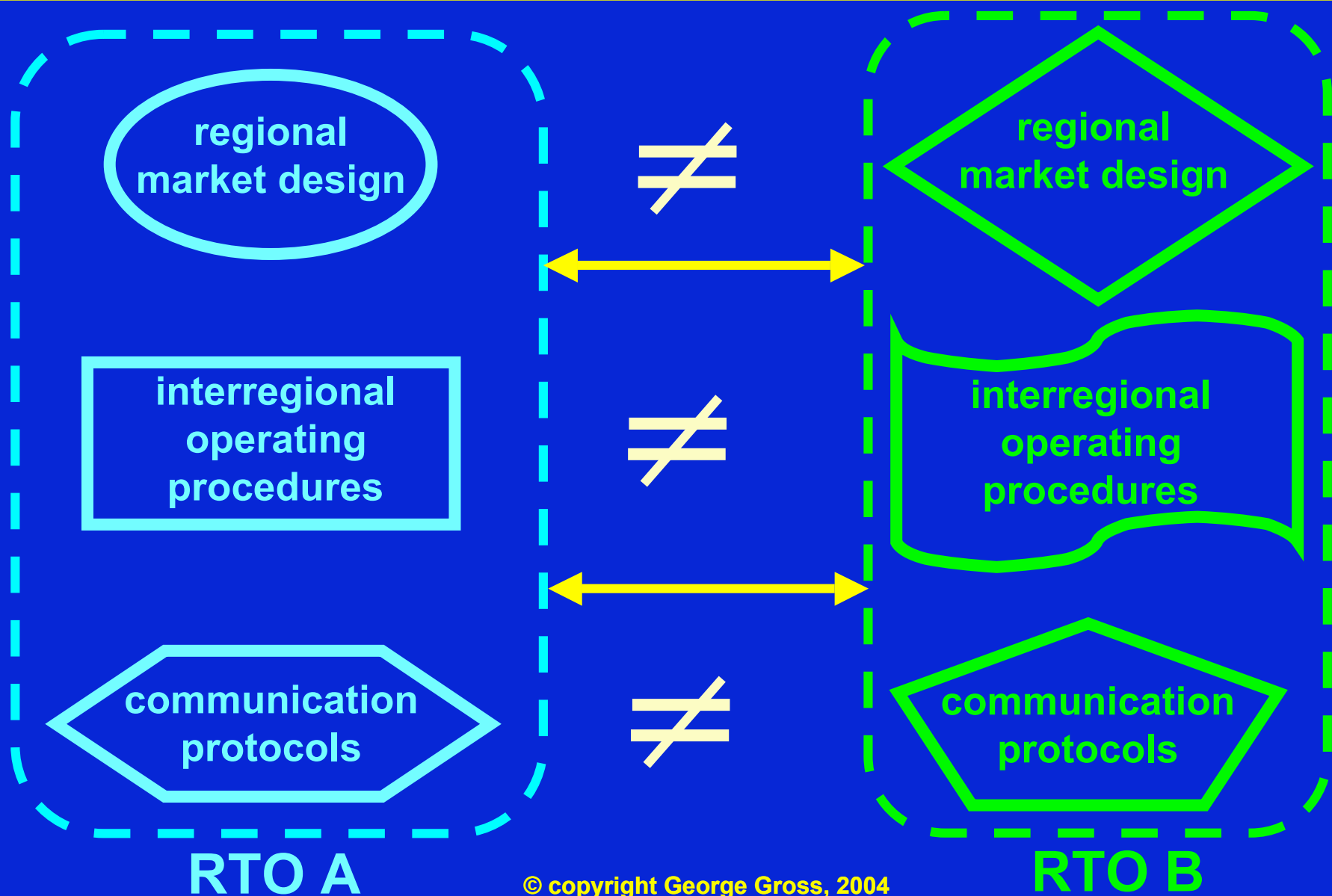
FLOW IMPACTS OF A TRANSACTION FROM RTO A TO RTO B



SEAMS ISSUES

- ❑ **Incompatibility between market designs may encumber the well-functioning of cross-border trades**
- ❑ **Such encumbrerment erects barriers to trading energy- and capacity-based services between interconnected markets**

SEAMS ISSUES



SEAMS ISSUES

regional
market design

interregional
operating
procedures

communication
protocols

RTO A

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regional
market design

interregional
operating
procedures

communication
protocols

RTO B

SCOPE OF SEAMS ISSUES

- ☐ Lack of coordinated system operations and planning
- ☐ Uncertainty in consummating transactions
- ☐ Increased opportunities for manipulative conduct
- ☐ Inefficiencies in interregional market trade

INTERREGIONAL TRADE: KEY CHALLENGES

- ❑ **Infrastructural improvements in**
 - **hardware: communication and IT investments**
 - **data: information exchange**
- ❑ **Specific needs in**
 - **transmission service coordination and pricing schemes**
 - **recovery mechanisms for capability improvement investments**

BOTTOM LINE

- ❑ Transmission is the weakest link of restructured electricity business
- ❑ Both operating and planning aspects of the transmission network provide us new challenges and opportunities in:
 - data management
 - real-time operations
 - congestion management
 - coordinated planning and expansion

THE POWER ENGINEERING DISCIPLINE

- ❑ Power engineering is among the oldest branches of electrical engineering and the field is deemed to be *mature*
- ❑ The wide interest in the newer fields, such as microelectronics, nanotechnology, computers, bioengineering and communications, has steadily eroded interest in power engineering
- ❑ The power industry has not had the type of *razzle dazzle* that, say, the computer and the other high-tech industries have enjoyed for many years

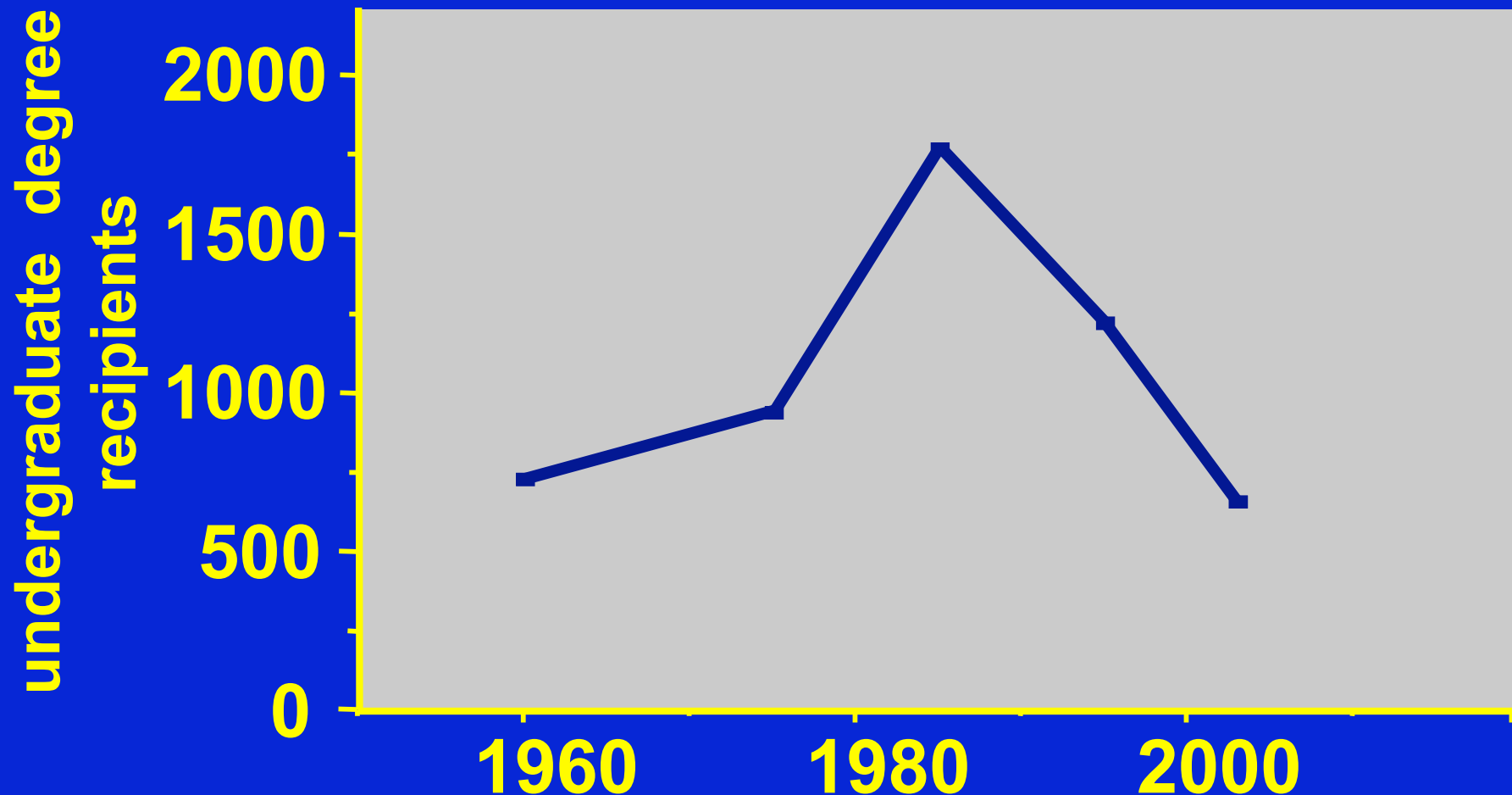
THE POWER ENGINEERING DISCIPLINE

- ❑ The restructuring of the electric power industry has dwindled support for power engineering programs and research; this support becomes further diminished by the extensive merger and acquisition trend in the industry
- ❑ The intensive reduction in engineering personnel at utilities has given the field a certain *black eye*
- ❑ The salary range of power industry offers is typically below that of other *hot* industries

THE POWER STUDENT ENROLMENTS

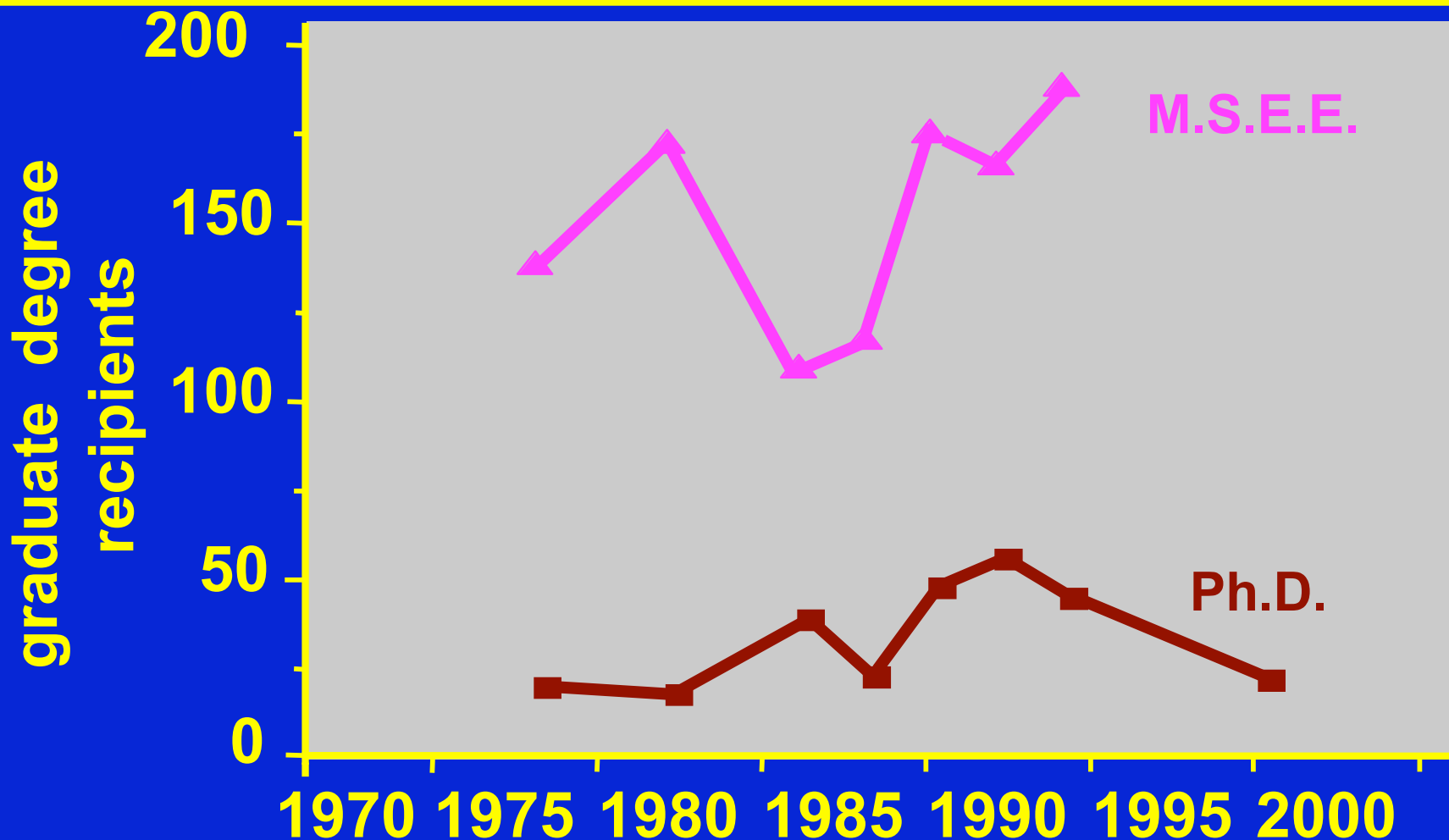
- ❑ The undergraduate student enrolment in the U.S. has been on a downward slope for many years
- ❑ The graduate student enrolment has been at a more steady level
- ❑ This level of the graduate enrolments has been due, to a great extent, to the large percentage of foreign students in the M.S. and Ph.D. programs

U. S. POWER ENGINEERING UNDERGRADUATE ENROLMENTS



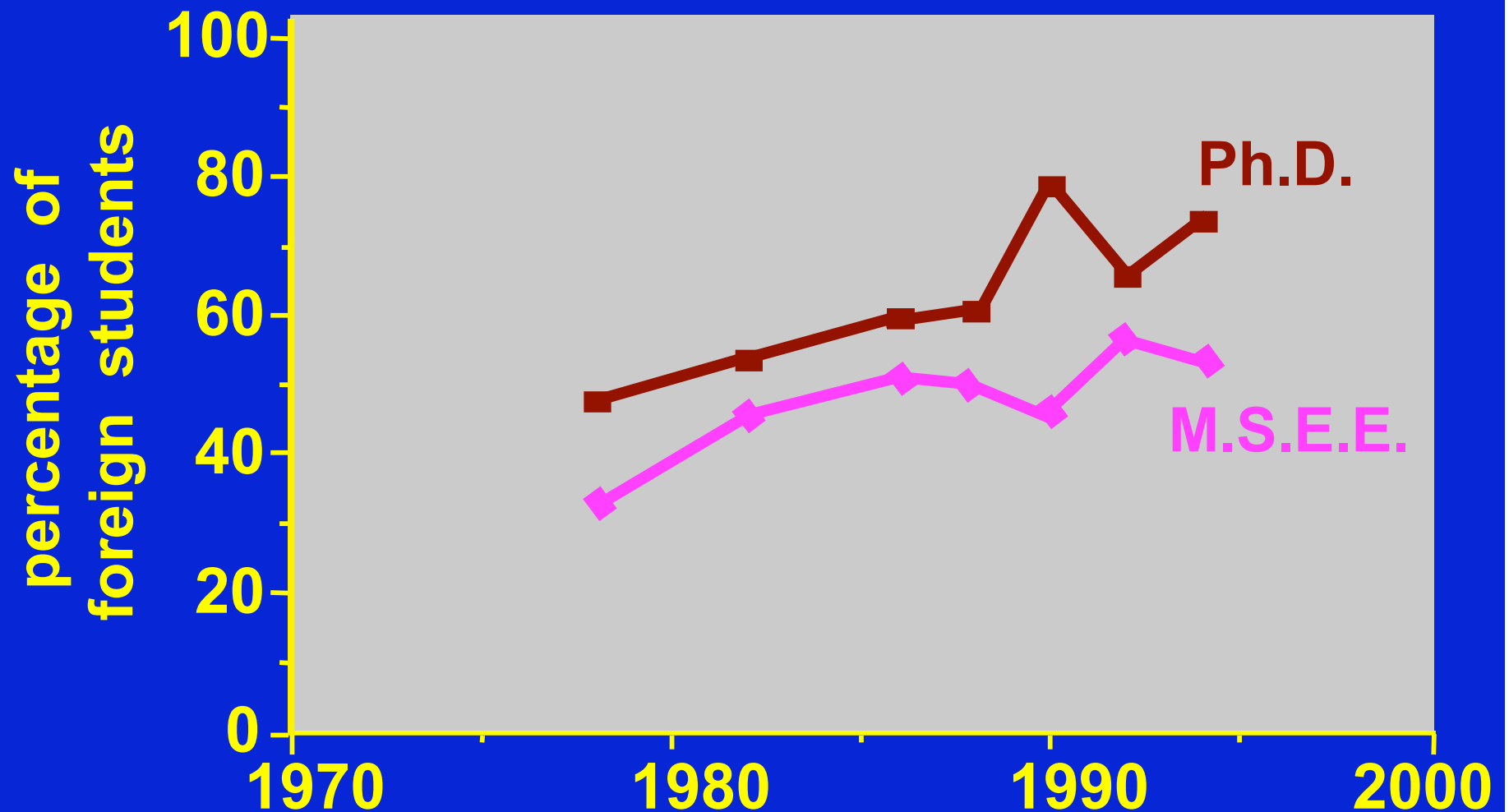
Source: G.T. Heydt and V. Vittal, "Feeding Our Profession," *IEEE Power & Energy Magazine*, vol.1, issue 1, Jan/Feb 2003, pp 38-45

U. S. POWER ENGINEERING GRADUATE ENROLMENTS



Source: G.T. Heydt and V. Vittal, "Feeding Our Profession," *IEEE Power & Energy Magazine*, vol.1, issue 1, Jan/Feb 2003, pp 38-45

FOREIGN GRADUATE STUDENT ENROLMENT



Source: G.T. Heydt and V. Vittal, "Feeding Our Profession," *IEEE Power & Energy Magazine*, vol.1, issue 1, Jan/Feb 2003, pp 38-45

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Suddenly, knowing a lot about the U.S. power grid became
sexy at cocktail parties.