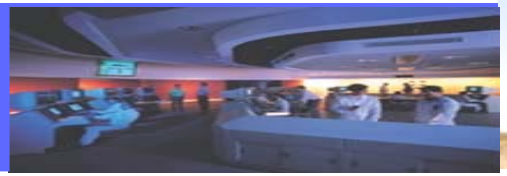
DOE Workshop on

Analysis and Concepts to Address Electric Infrastructure Needs

Washington DC

August 3, 2001



New Concepts for the Transmission Grid

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Major Functions of the Transmission System

- **Deliver electricity from generators to areas of customer demand**
- **Provide flexibility for contingencies**
  - outages of generators and transmission circuits
  - higher than expected demand
  - fuels shortages
- **Reduce the needed installed generating capacity**
  - allow sharing of generation capacity among utilities
  - provide diversity in peak demand and generation availability
  - reduce individual utilties' investment in generation facilities
- **Allow economic exchange of electricity**
  - use of most economic generation
  - maintain reliability

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Issues in Electricity Transmission

- The transmission system is being used for a different purpose than originally designed
- New role: interstate highway for commerce
- Number of transactions has exploded due to deregulation
- Uncertainty in the regulatory environment
- Declining transmission investment has resulted in insufficient capacity
- New demands and insufficient capacity have created congestion with price and reliability impacts

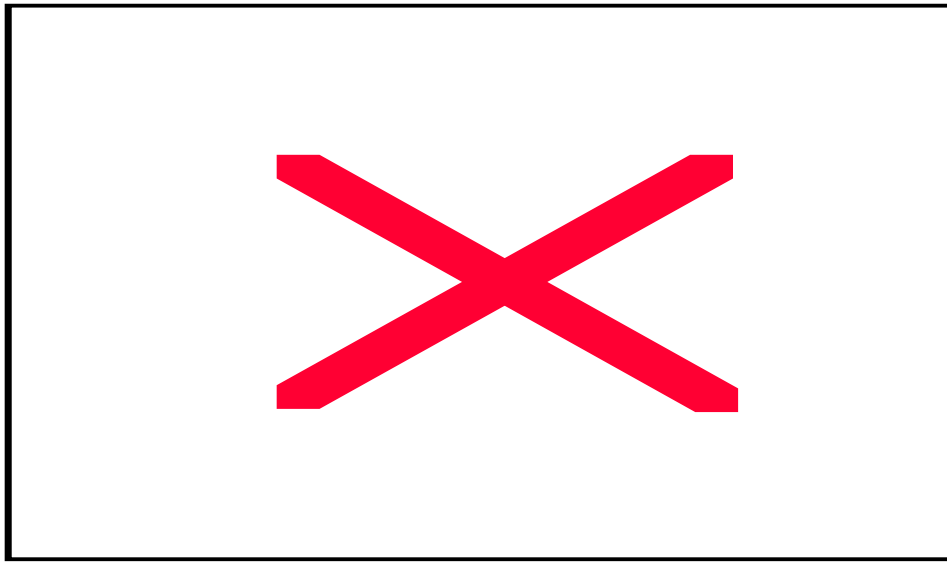
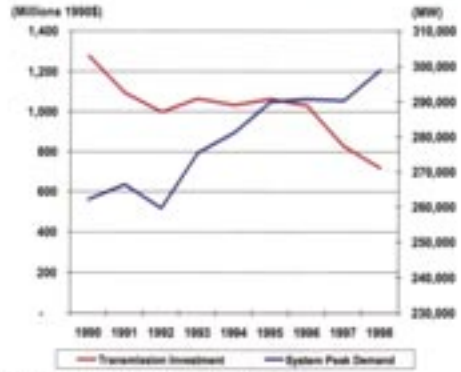


Figure 5

U.S. Net New Transmission Investment v. System Peak Demand Growth



Source: PA Consulting based on data from the UDI database

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Barriers to Transmission Investments

- Multiple authorities and responsibilities for planning and building new facilities
- Regulatory framework for cost recovery of transmission expansion
- Siting and permitting of new transmission facilities
- Regulatory uncertainty

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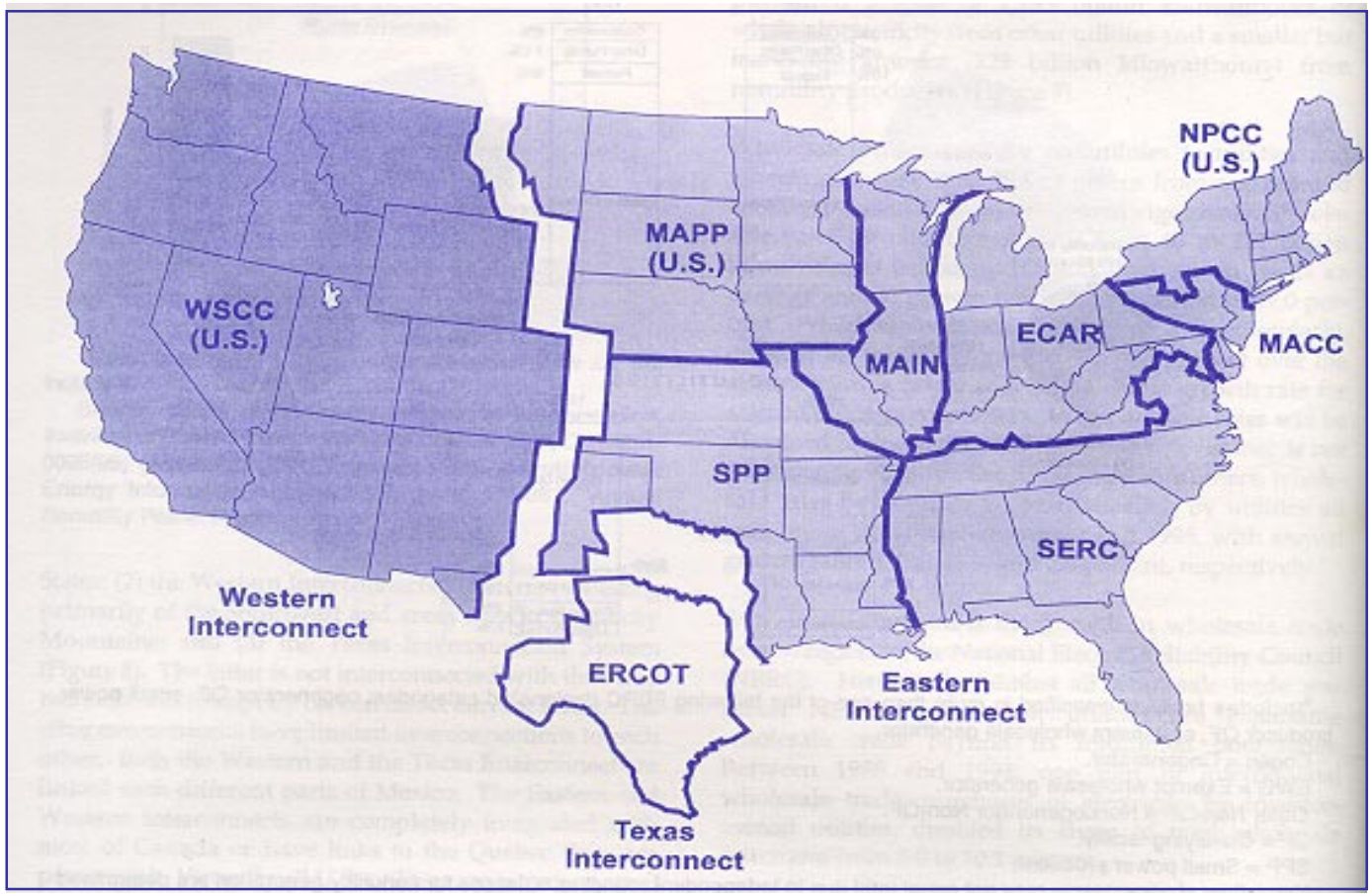
Some Principles in Regulatory Reform for Transmission

- Streamlined siting authority process to increase certainty and speed
  - Ensure consideration of regional/interstate benefits in siting process (reliability and market benefits)
  - Promote integration of regional markets
- The rate of returns must recognize the value that the transmission grid plays in the economy.
  - Implement Performance Based Rate Making
  - Include clear signals on congestion and losses to transmission users
  - Rates should encourage technological innovation
- Promote implementation of environmentally and community friendly technologies

Encourage Regional Planning



- **FERC has ordered formation of four Regional Transmission Organizations**

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Cost of transmission is small

- The cost of the transmission grid is small compared to the total cost of delivered electricity.
  - Generation 64%
  - Distribution 25%
  - Transmission 11%
- T&D costs is very variable
  - cost of a new line can run from $1.5 million per mile to $80 million in highly populated areas
- New demands and insufficient capacity have created congestion with price and reliability impacts

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Role of Transmission as the interstate highway

- Options to increase transmission capacity
  - Build new lines
    - AC
    - DC
    - this require new rights-of-way
  - Upgrade lines in existing ROWs
    - increase voltage
    - increase conductors
  - Utilize existing capacity better
    - FACTS
    - “intelligent grid”
    - storage

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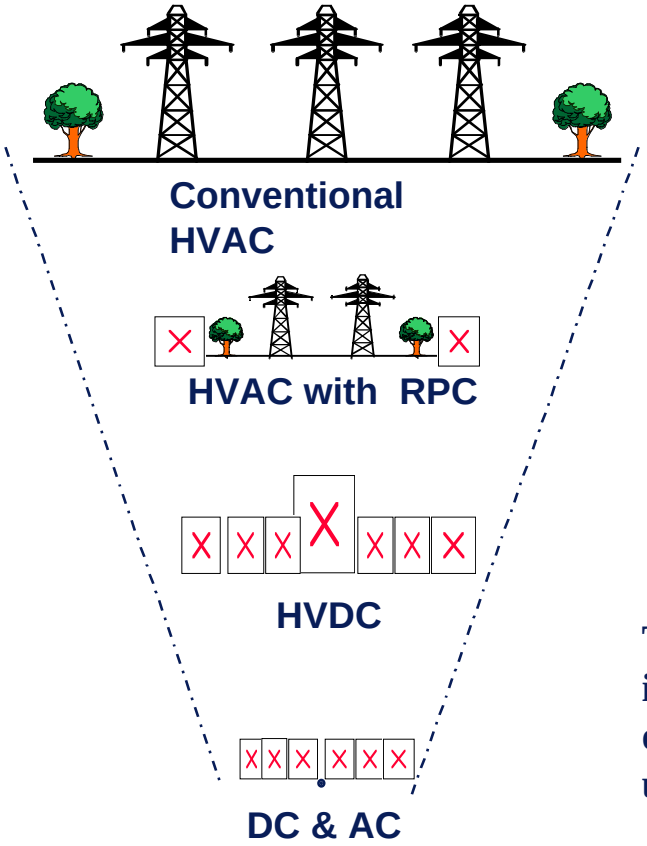
New Transmission Solutions

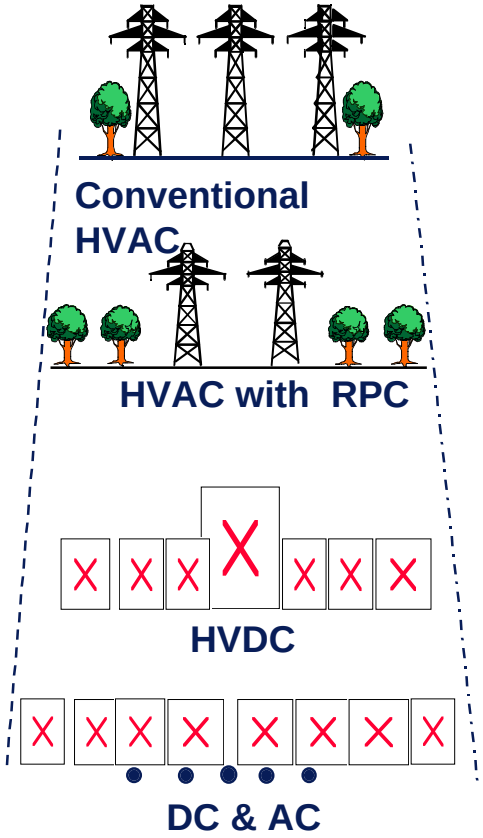
Widening the market for high-tech solutions



Facts and RPC

HVDC

Transform the infrastructure from overhead to underground



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Technology Solution -- HVDC / HVDC Light

High-Voltage Direct-Current Transmission is a superhighway or pipeline for efficient point-to-point delivery of power

Characteristics of HVDC /HVDC Light

- **Power is injected where needed**
- **No inadvertent flow -- mitigates loop flow**
- **Bypasses congested circuits**
- **Demands no reactive power**
- **Controls both real and reactive power**
- **Provides dynamic reactive power reserve and voltage regulation**
- **No limit to underground cable length**
- **Modular and expandable**
- **Easier permitting and ROW acquisition**

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Emerging : - Merchant Transmission

New technology - HVDC Light Cross Sound Cable, USA

Problem

- Connect Long Island with large N Eastern generation pool to allow trading

Solution

- Unique totally underground/sea easily permissible, fast-track technical solution, 330 MW HVDC Light System
- Project developed together with world-class project developer, Transenergie
- Order value 120 MUS$

Benefits

- Enhanced reliability with reduced environmental impact

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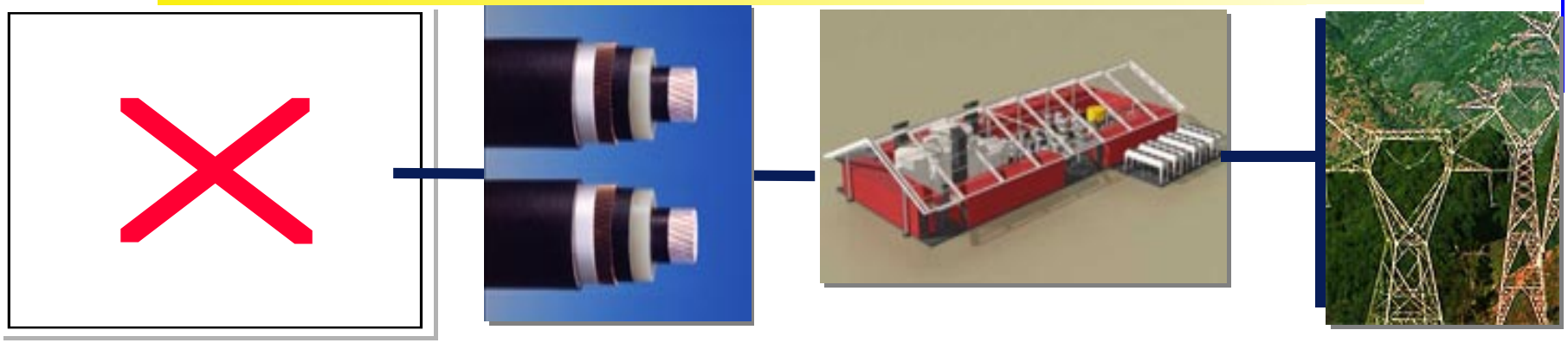
Renewable Energy Integration

- **Integrated solution for electricity generation and distribution for medium and large power wind farms**



Windformer

HV DC generator

DC Cable transmission

DC/AC converter

Grid

Feed cities with wind power collected in remote areas through underground transmission with reduced footprint

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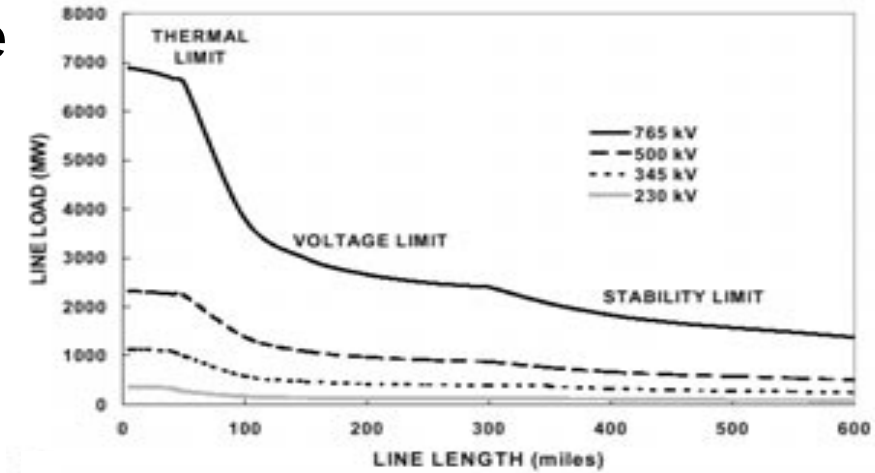
New AC lines and upgrades

- AC line capacity by voltage and conductor
  - Typical thermal capacity ratings:
    - 230 kV - 400 MW
    - 345 kV - 1100 MW
    - 500 kV - 2300 MW
    - 765 kV - 7000 MW
  - Constraints
    - Thermal
    - Voltage
    - Stability
- Convert AC lines to HVDC
  - more than double the capacity
  - no thermal, voltage or stability constraints
  - flow controllability



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HVDC Transmission -- More Efficient

- More power can be moved down the right-of-way
- For an AC line with the same conductor and insulators per phase, losses would be 50% higher

Less environmental impact!

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Better Utilization of existing capacity

- Application of FACTS devices
  - SVC, TCSC, STATCOM, UPFC
  - These can boost transmission capacity by as much as 30%
- Application of “intelligent devices and controls
  - smart algorithms to detect voltage instability
  - use of IT,wide area control,dynamic rating, etc can improve capacity utilization by as much as 15%

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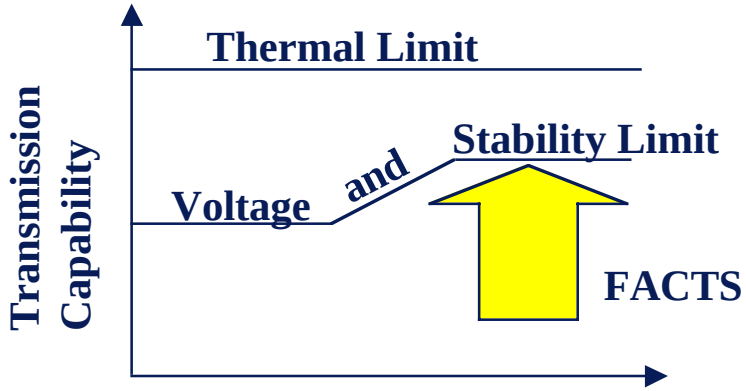
Influence of RPC/FACTS on Transfer Capability

Flexible AC Transmission Systems (FACTS) and wide area controls can improve capacity utilization and control power flow



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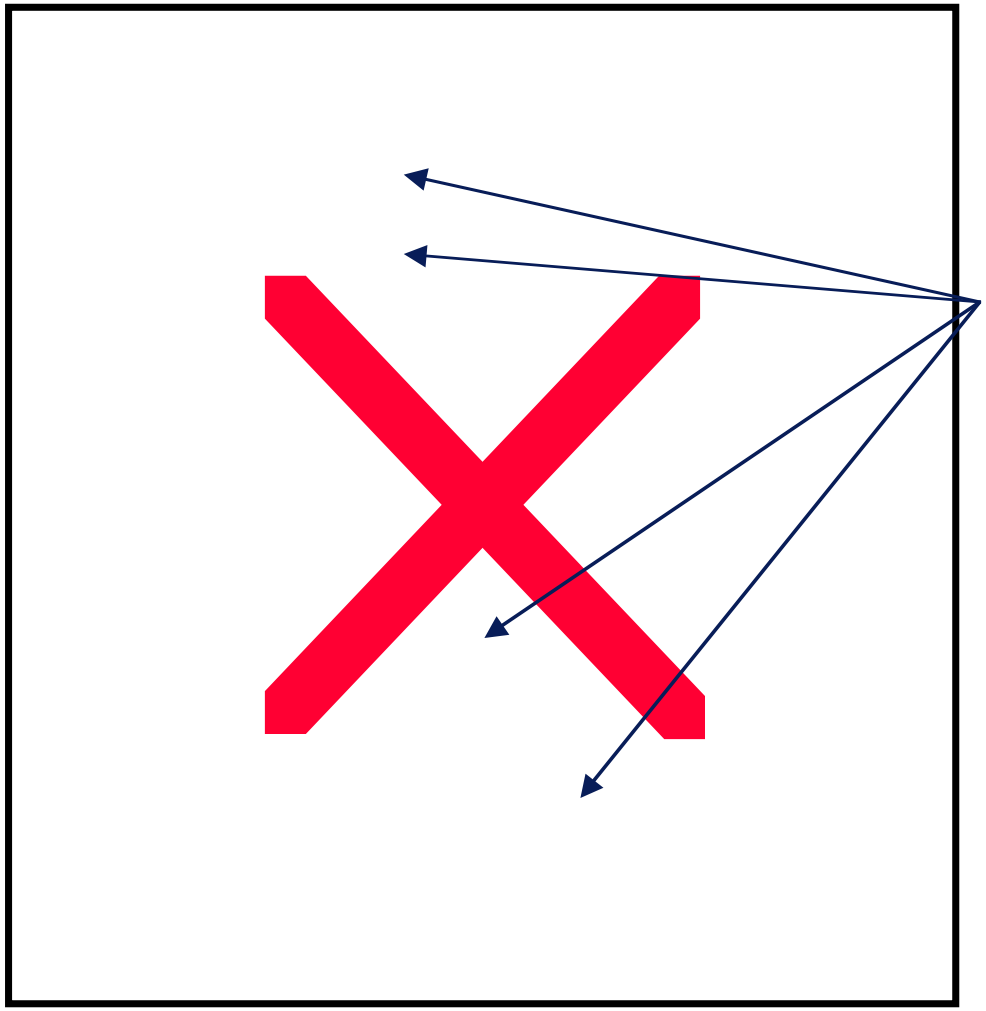
PG&E Series Capacitor Project



Problems

- More power needed in California
- Transmission system at thermal and voltage limits

Solution

- **Series Compensation**

  10 SC banks at 4 different locations:

  Table Mountain, Round Mountain, Los Banos, Midway

Benefits

- Power import increased from 3600 to 4500 MW
- Lower transmission losses

Alternatives

- New transmission line from the Northwest to California
- New generation in California.

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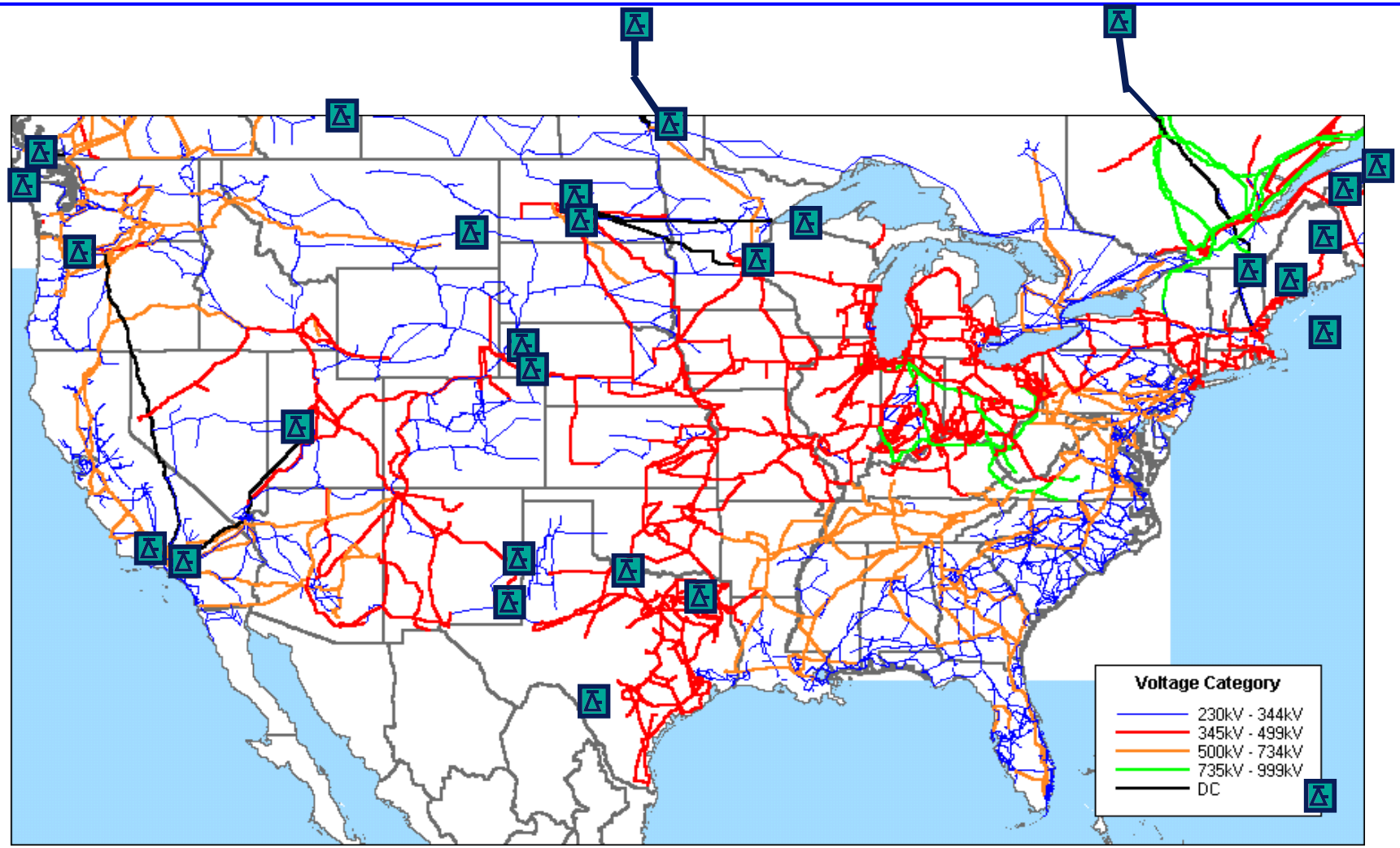
Elements of a National Grid ?



A National Grid: connect the HVDC dots?

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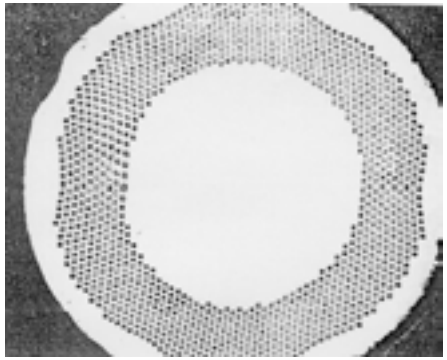
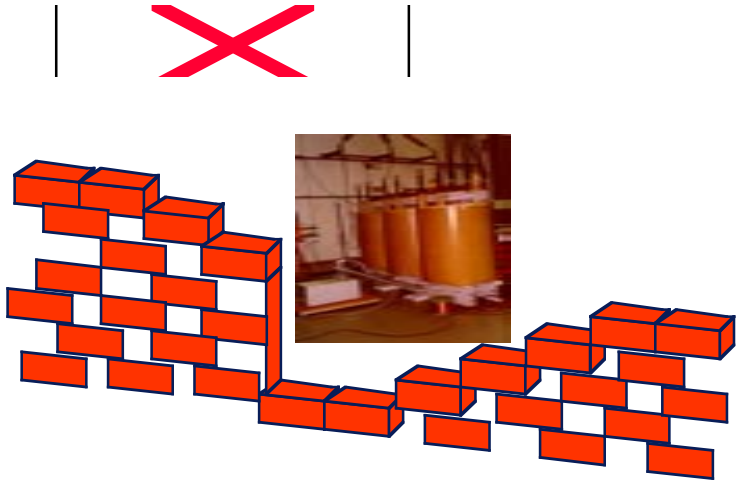
HTS technology can play an important role

Characteristics of HTS Devices

- HTS Transformers
  - low losses
  - low Var requirements
  - Result: Improves grid voltage profile
- HTS Cables
  - High capacity
  - low losses
  - long length without RPC
  - small ROW needs
  - Result:
    - combine with HVDC to bring power to large load centers
    - upgrade capacity in mega cities
- SMES
  - storage and power flow modulation





There is tough competition out there

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Summary: New Paradigms in Transmission

- Adequate transmission capacity is vital to an efficient electricity market
- Existing cost of service rates are not reflecting the economic value of the transmission grid
- The barriers to transmission expansion must be resolved
- Failure to address these transmission issues will result in:
  - limited competition in whole sale markets
  - increased price volatility due to congestion
  - reduced system availability and reliability

Technology is not a barrier, but development and use of new technologies must be encouraged through performance based ratemaking

• must find the commercial argument for HTS

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