

DUMB GRIDS, SMART GRIDS, OUR GRIDS

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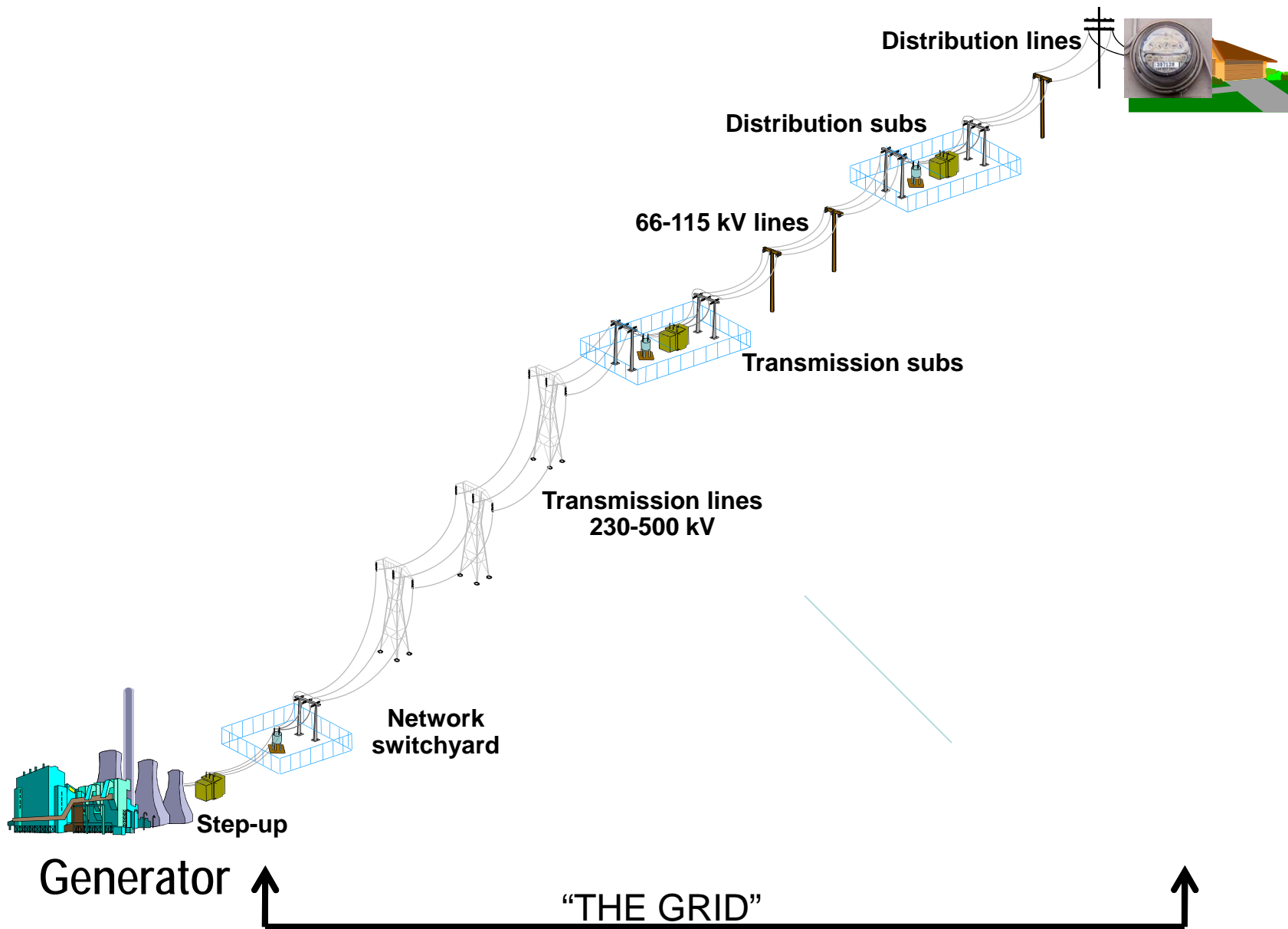
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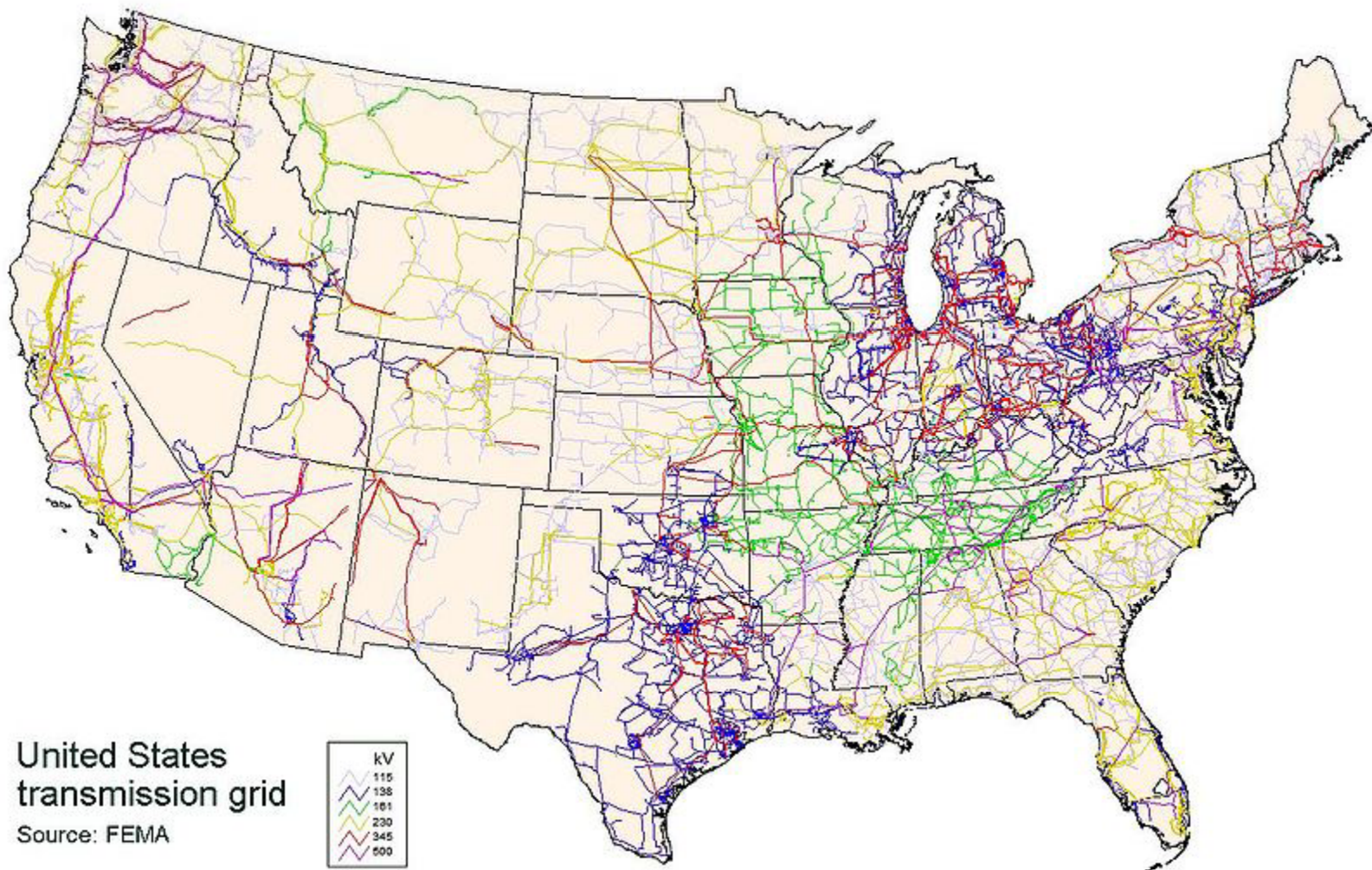
SOME BASIC FACTS ABOUT ELECTRICITY SECTOR

- Accounts for 42% of primary U.S. energy consumption
- Accounts for 35% of U.S. fossil fuel consumption
- Accounts for 40% of U.S. CO₂ emissions and this share projected to grow in BAU
- Uses almost no petroleum: Oil accounted for 17% of generation in 1973 and only 1% today
- Relies primarily on North America for fuel
- Solar + Wind ~ 2.0% of total electricity generation but growing fast
- Electricity consumption projected to grow faster than total energy consumption

SMART GRID INVESTMENT IS “IN”

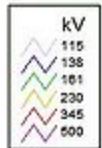
- 2009 Federal stimulus bill designated about \$3.5 billion for “innovative” smart grid investment grants, pilot programs and R&D
 - About 2/3 allocated so far
 - Very little has actually been spent
- A growing number of states have ordered electric utilities to make “smart grid” investments of one type or another and include the costs in regulated distribution prices



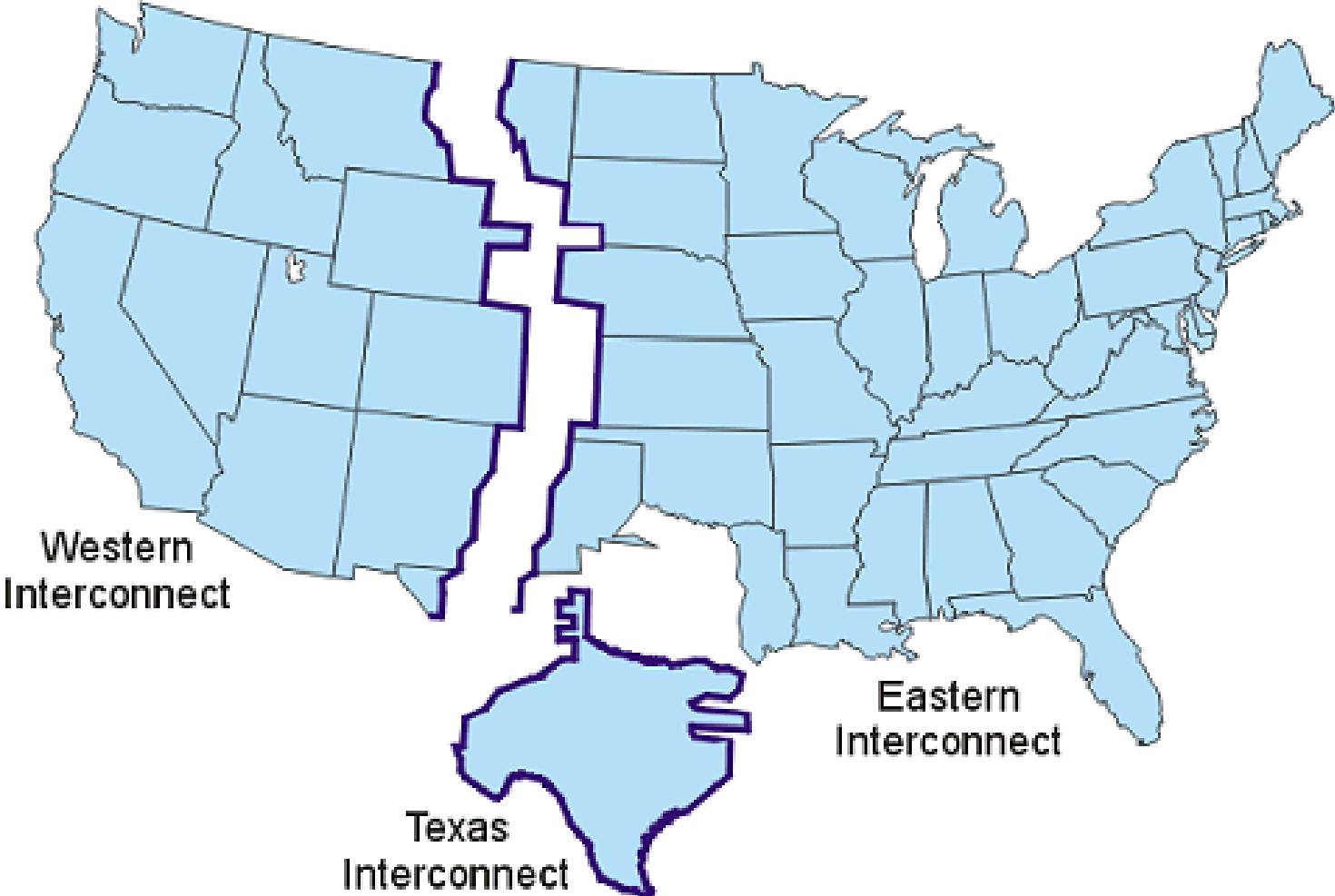


United States
transmission grid

Source: FEMA

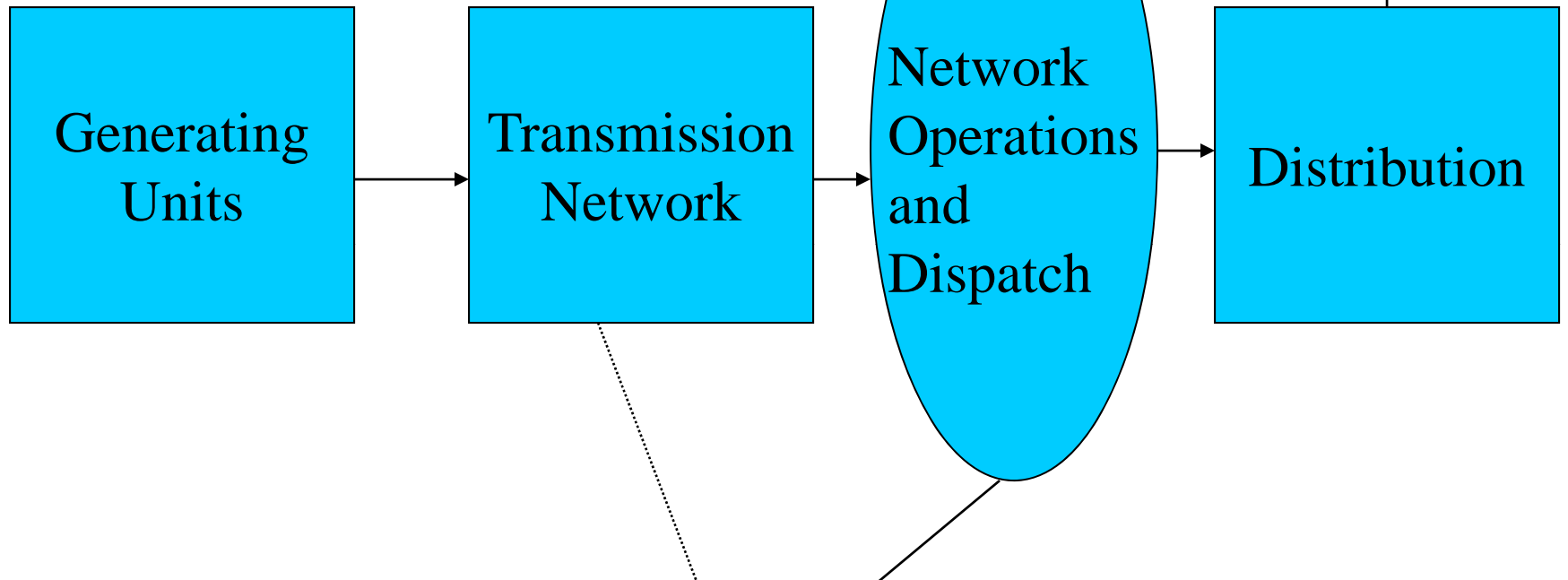


North American Electric Power Grids

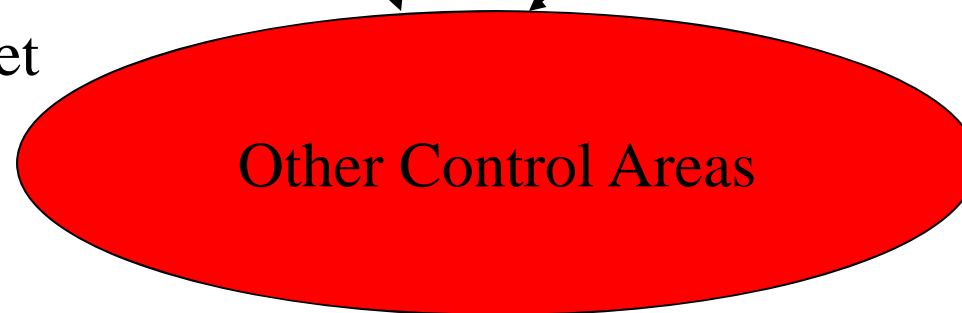


Source: NERC

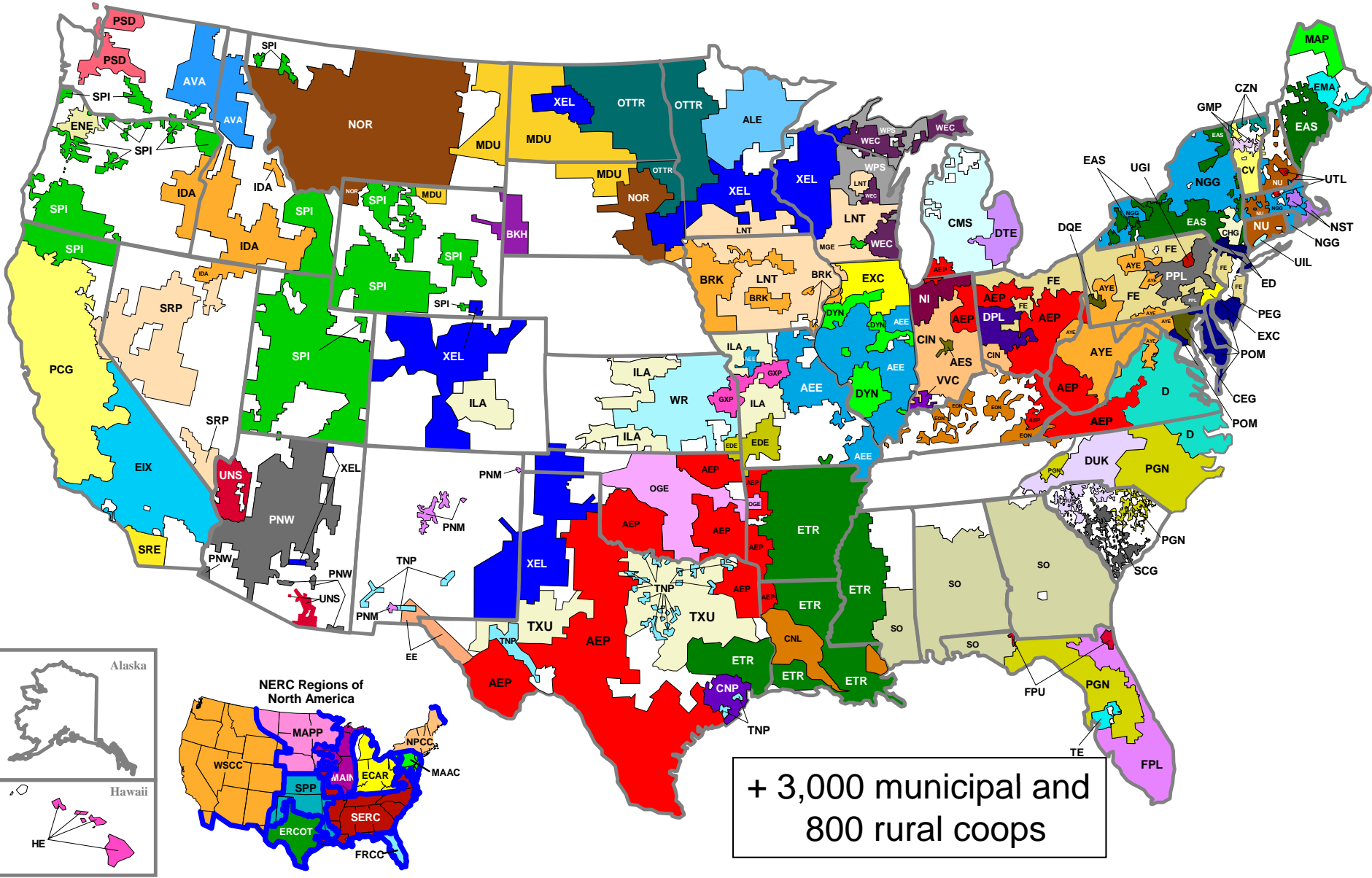
Vertical Integration + Monopoly + COS Regulation



Wholesale Market



U.S. Investor-Owned Electric Utility Holding Companies as of January 2004

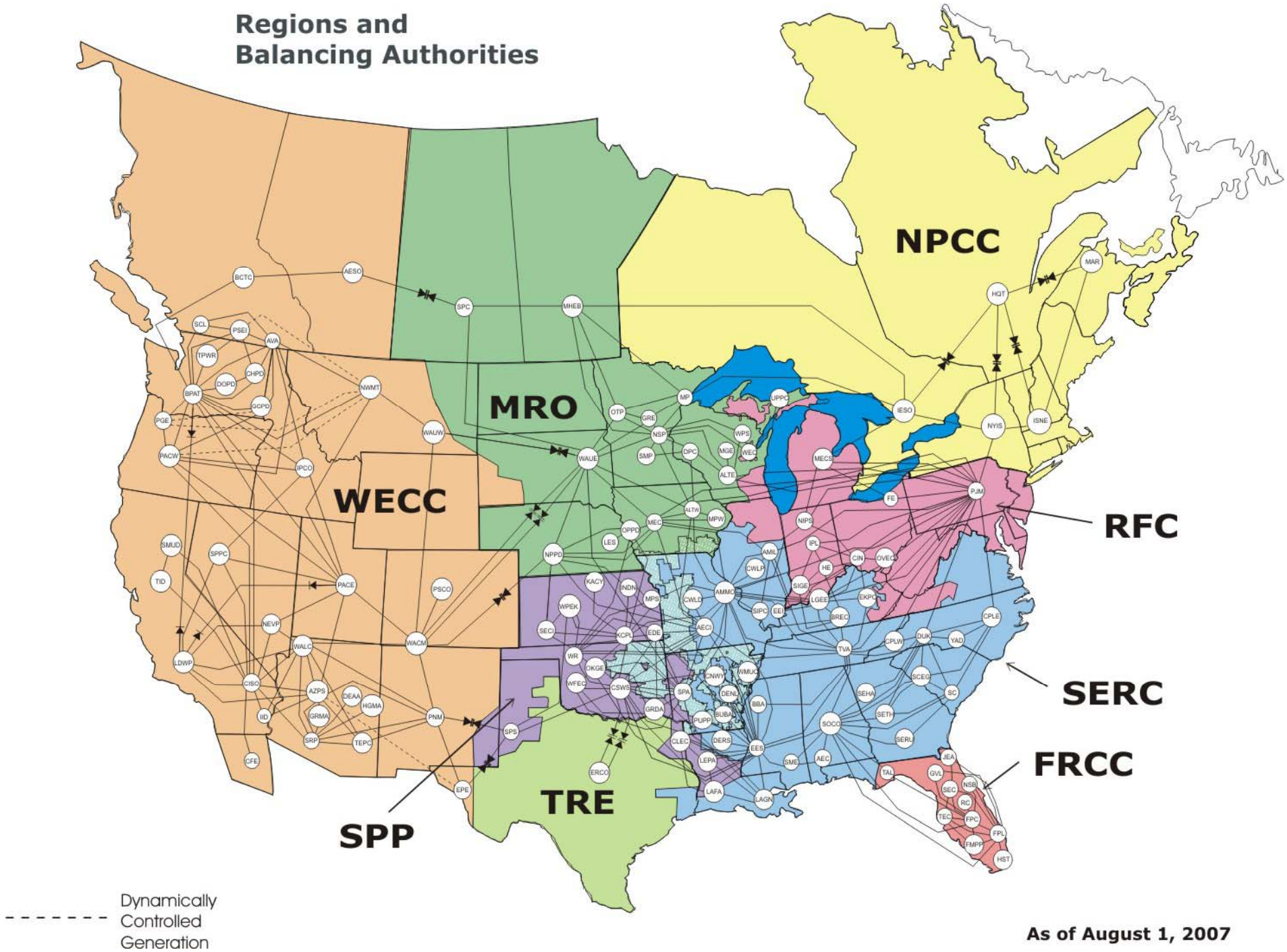


+ 3,000 municipal and
800 rural coops

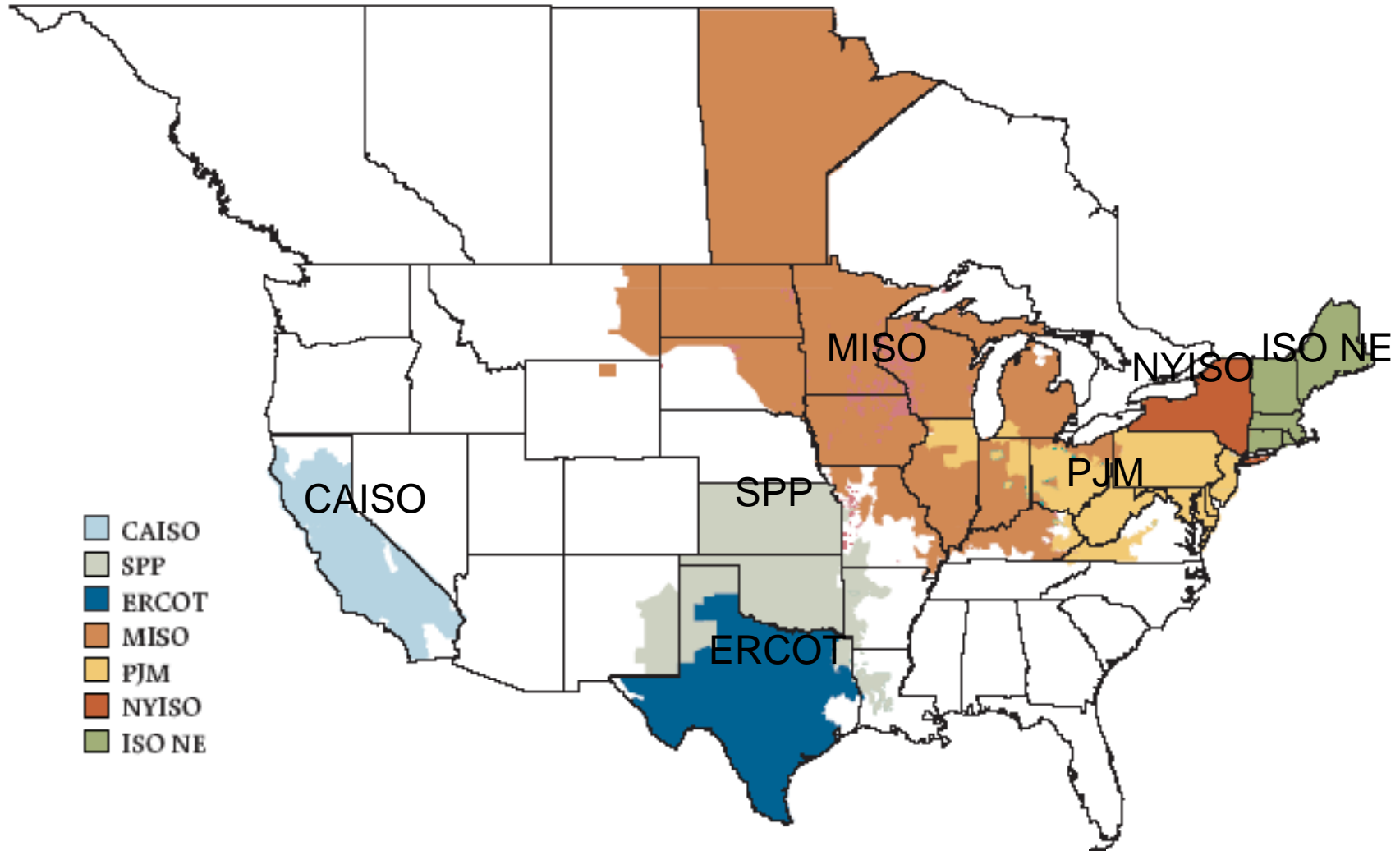
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The service boundaries on this map are a general representation of individual utility regions and do not necessarily depict the exact legal boundaries of the regions. Information on this map is believed to be accurate but is not guaranteed.

Regions and Balancing Authorities

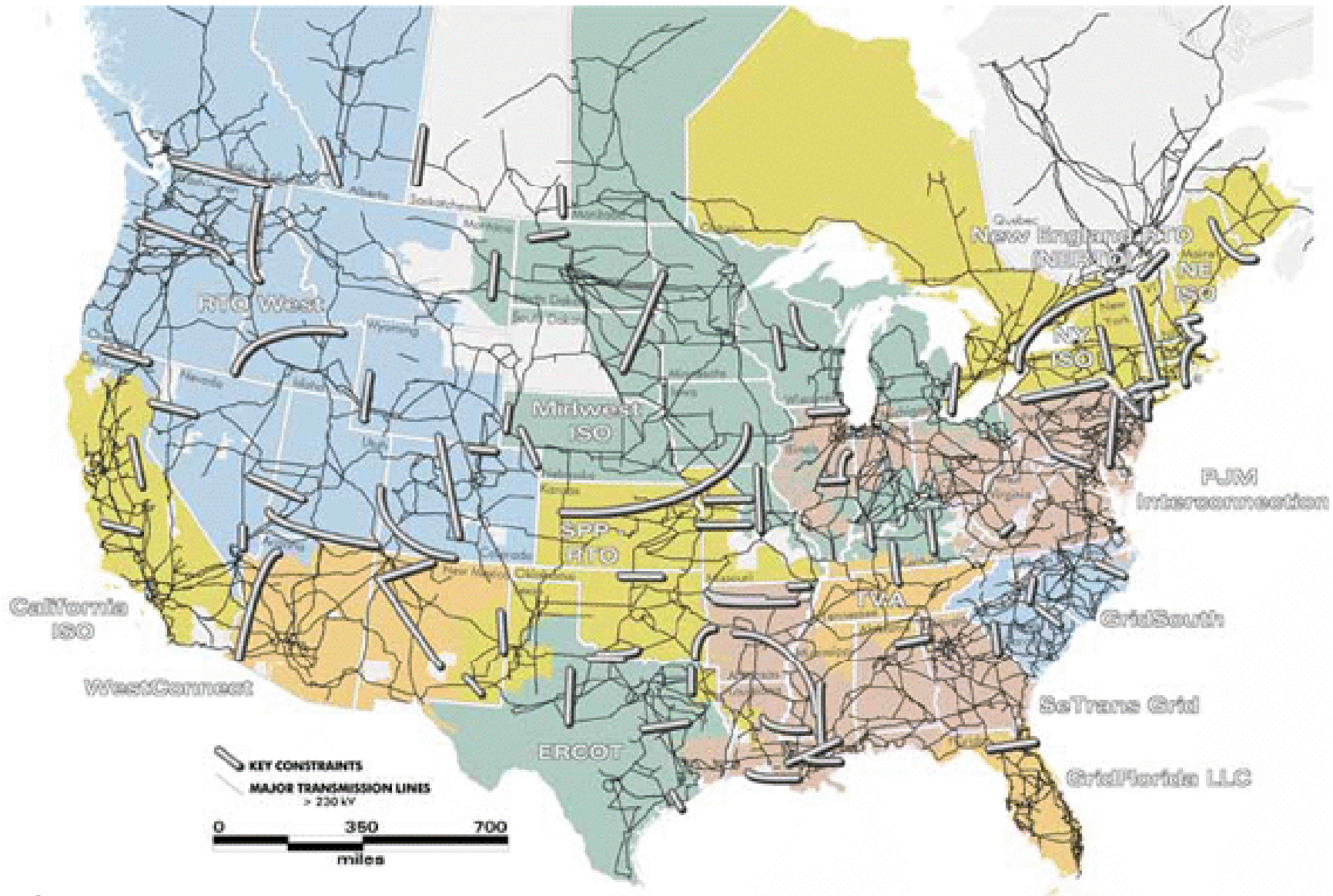


ISO/RTOs in the United States 2006



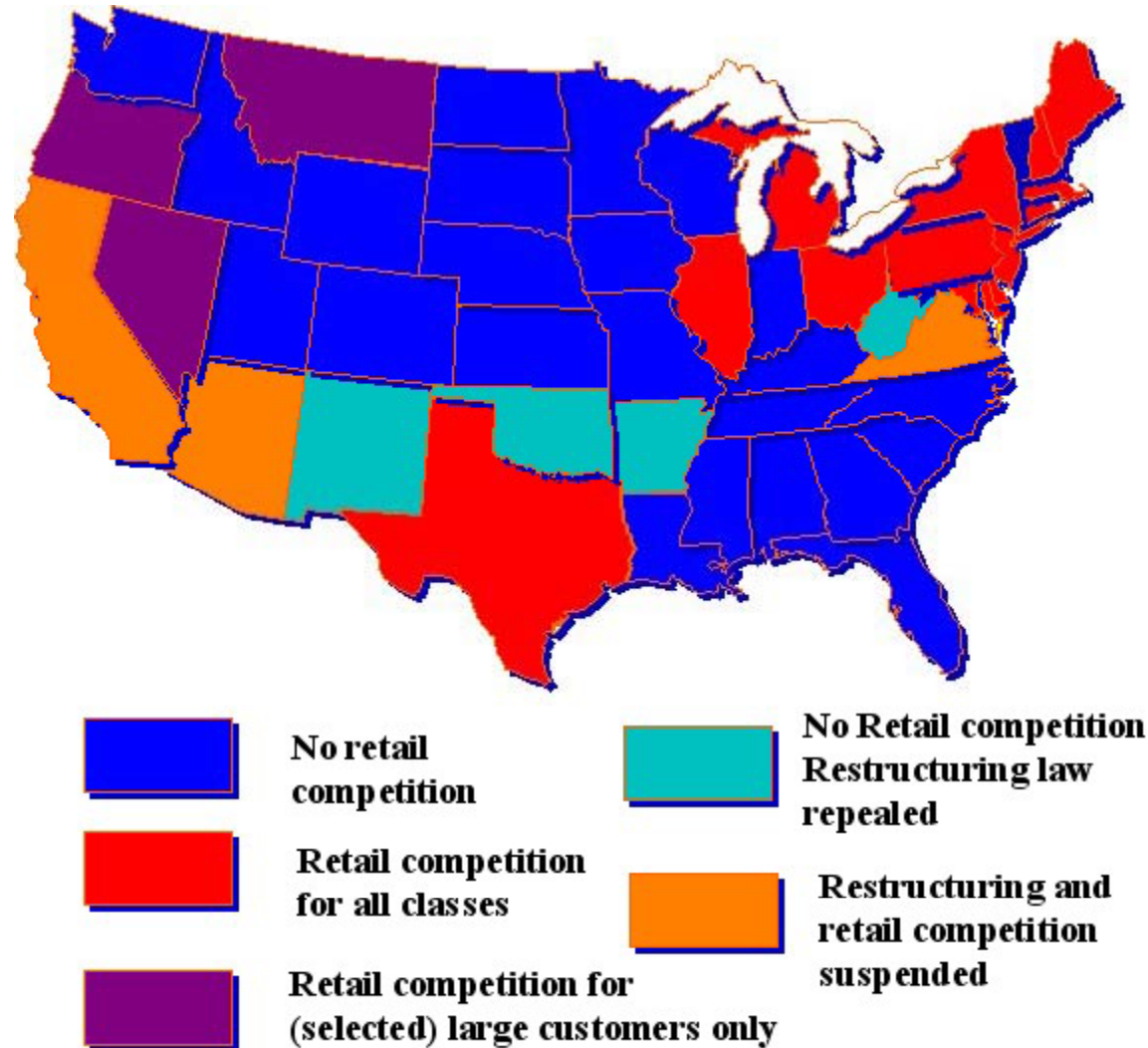
Source: State of the Markets Report 2004, FERC Office of Market Oversight and Investigations (2005, page 53).

MAJOR CONGESTED INTERFACES



Source: Platts

STATUS OF RETAIL COMPETITION AND RESTRUCTURING REFORMS 2007



WHAT IS A SMART GRID?

- “Smart” end-user meters
 - Current meters for residential and small C&I customers are “dumb”
 - Smart meters allow for real time pricing
 - Smart meters allow for remote reading
 - Smart meters can have advanced communications capabilities
 - Smart meters + real time pricing create incentives for real time control of appliances and equipment with necessary communications and control features



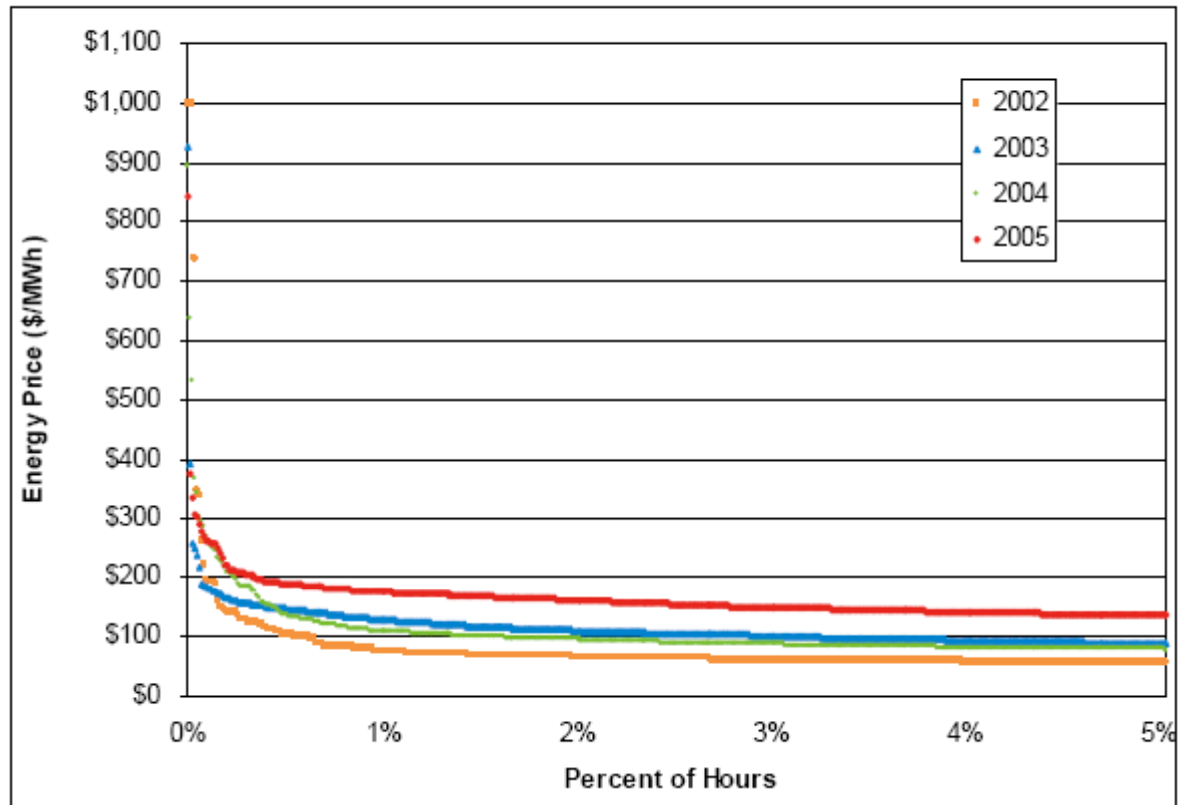
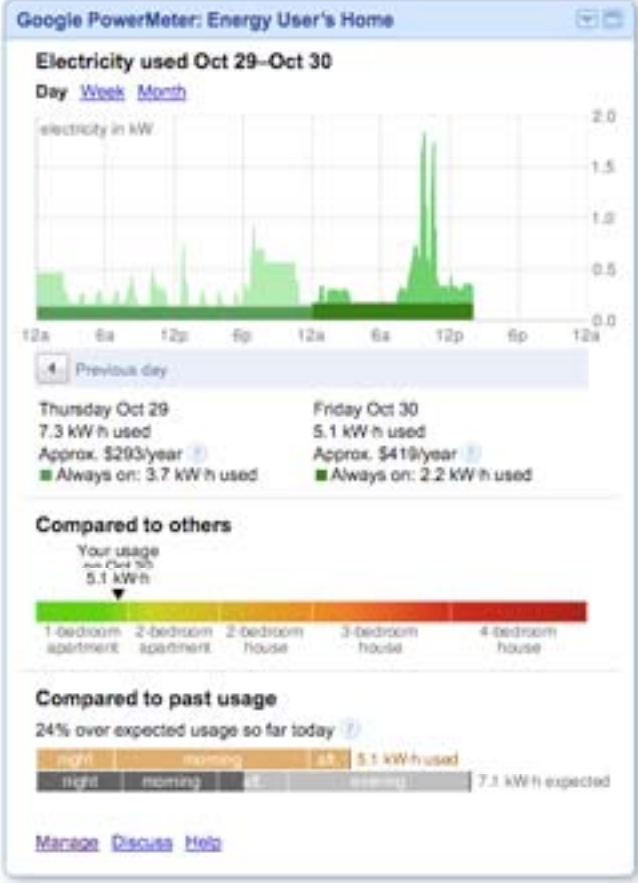


Figure 3-23: System real-time price-duration curves, prices in most expensive 5% of hours, 2002–2005.

Note: System price is the single energy-clearing price for the Interim Market period ending February 28, 2003, and load-weighted Real-Time Energy Market LMPs for March 2003 to December 2005.



Smart Meter Issues

- Do the consumer benefits exceed the costs?
- Smart meters cost ~ 5 times traditional residential and small commercial meters
- Remote meter reading ends the need for meter readers and this may account for as much as 50% of costs savings
- Data management and analysis is costly
- Allows real time pricing to give consumers better price signals to decide when and how much to consume
 - Peak prices could be as much as 1000 times off-peak prices

Smart Meter Issues

- Short run vs. long run responses uncertain
 - Consumers must be able to see and react to real time price signals
 - Requires investment in communications, monitoring and control equipment
 - Or retail supplier must offer simpler contractual arrangements (e.g. AC cycling)
- Technology to control equipment and appliances in response to price signals and from remote locations is important, must be deployed and is still evolving
- There will be gainers and losers

WHAT IS A SMART GRID?

- Improve real time monitoring and control of the distribution network
 - Improve network reliability and response to failures --- distribution network is the most “unreliable” piece of the system
 - More efficient network utilization
 - Accommodate small scale generation connected to homes and business or the distribution network
 - Costs and benefits are very uncertain

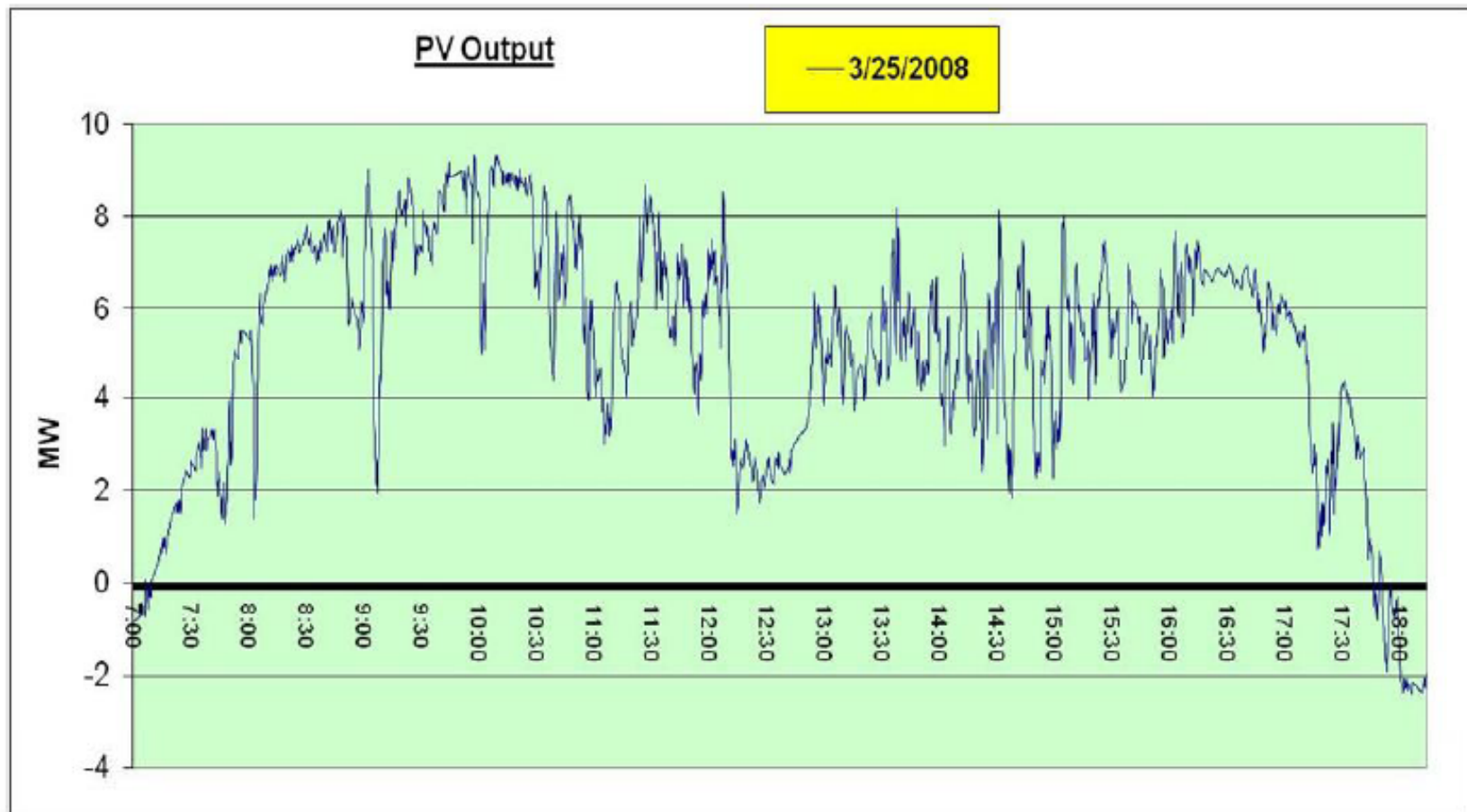
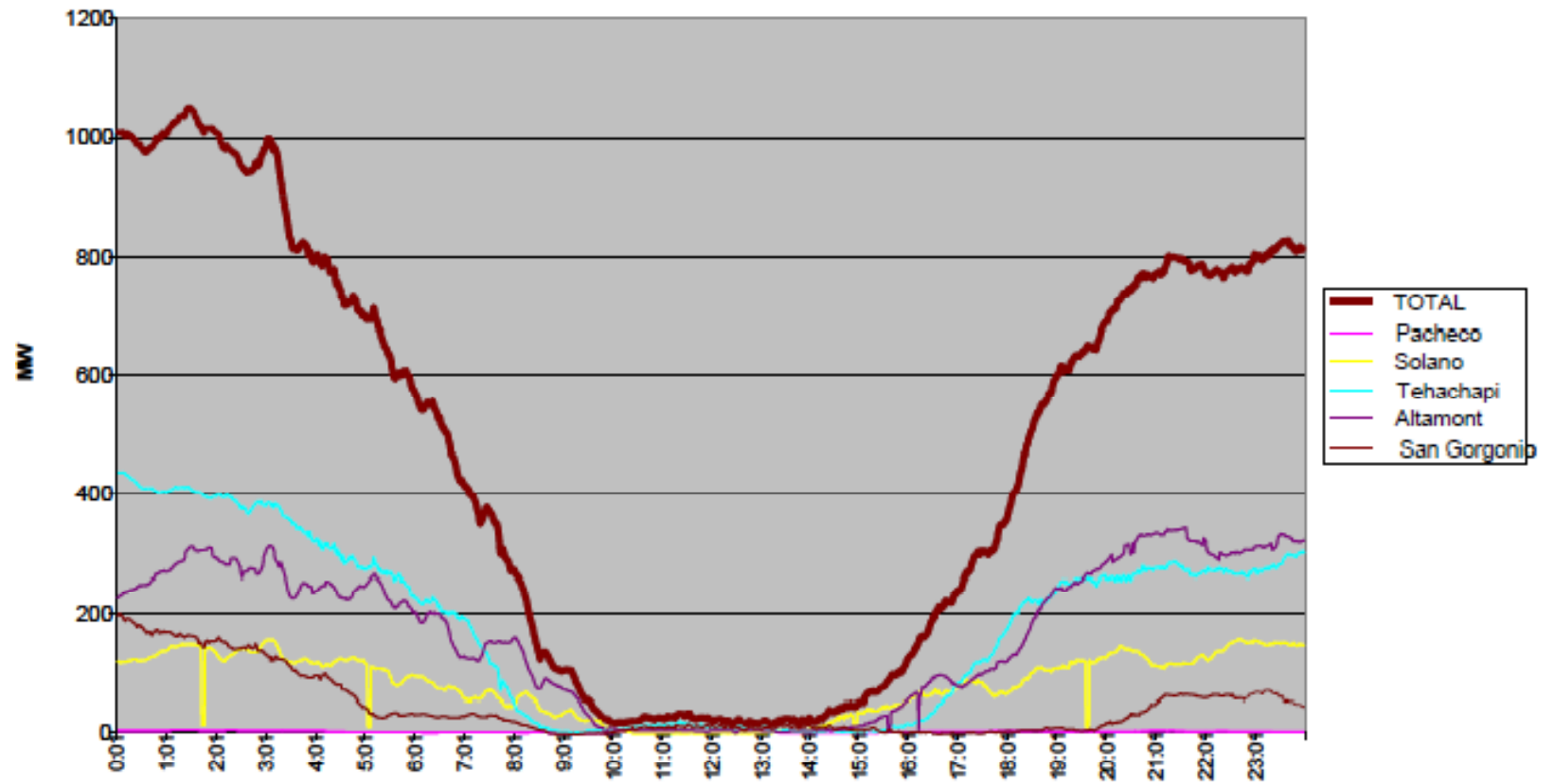


Figure 2.12: PV Plant output on a partly-cloudy day (Sampling time 10 seconds)

WHAT IS A SMART GRID ?

- Improve real time monitoring and control of the high voltage transmission network
 - Improve reliability by enhancing real time monitoring and control
 - Increase effective capacity of the high voltage grid by reducing contingency-related congestion
 - Large scale intermittent generation (wind and centralized solar) makes efficient and reliable network utilization a more challenging problem
 - Costs and benefits are uncertain

Total California Wind Generation



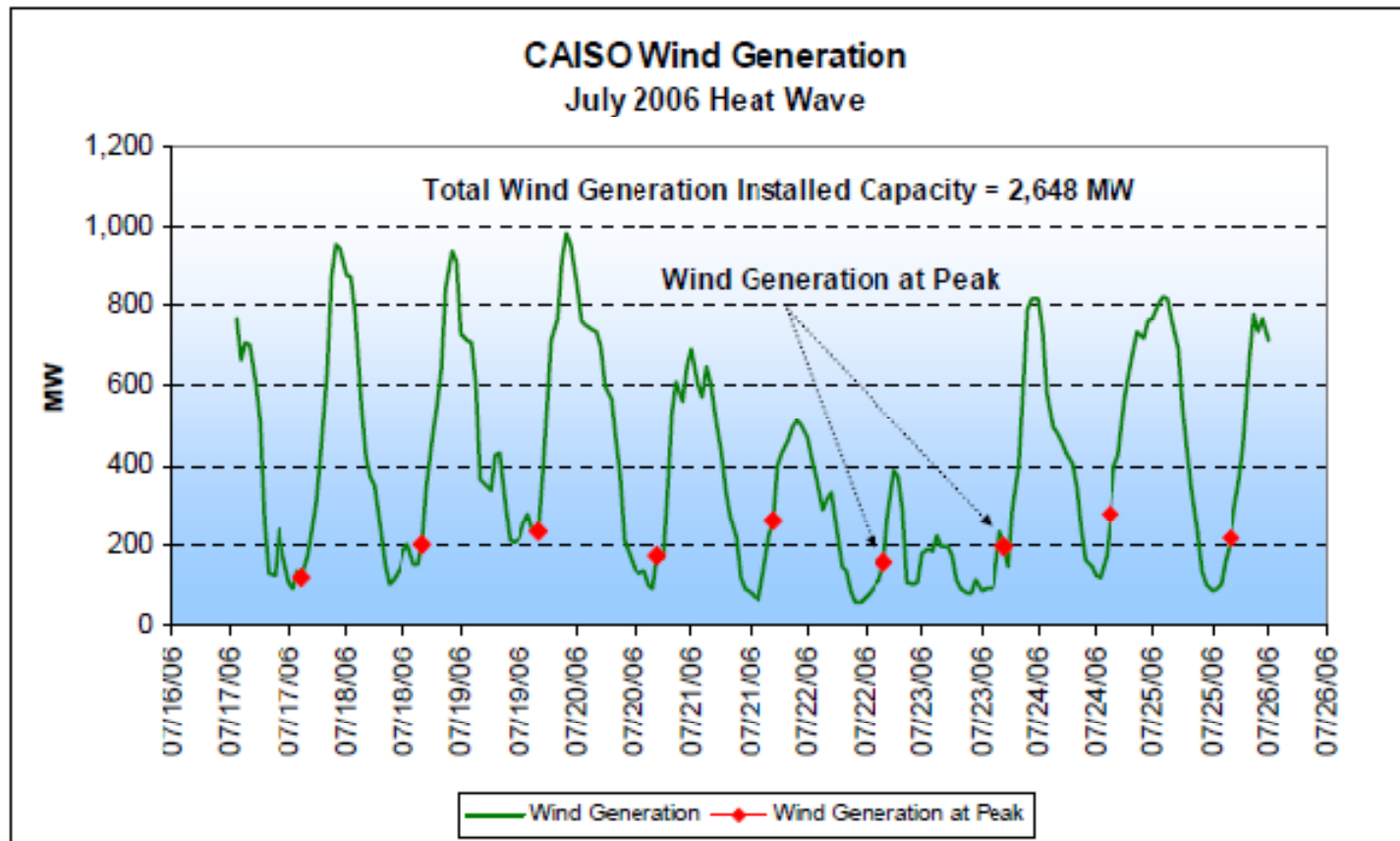


Figure 3.2: CAISO wind generation during the 2006 heat wave

WHAT ISN'T A SMART GRID ISSUE?

- Building more transmission lines to bring power from renewable sources located at remote locations to where it is consumed
- An important grid issue but not a “smart grid” issue per se

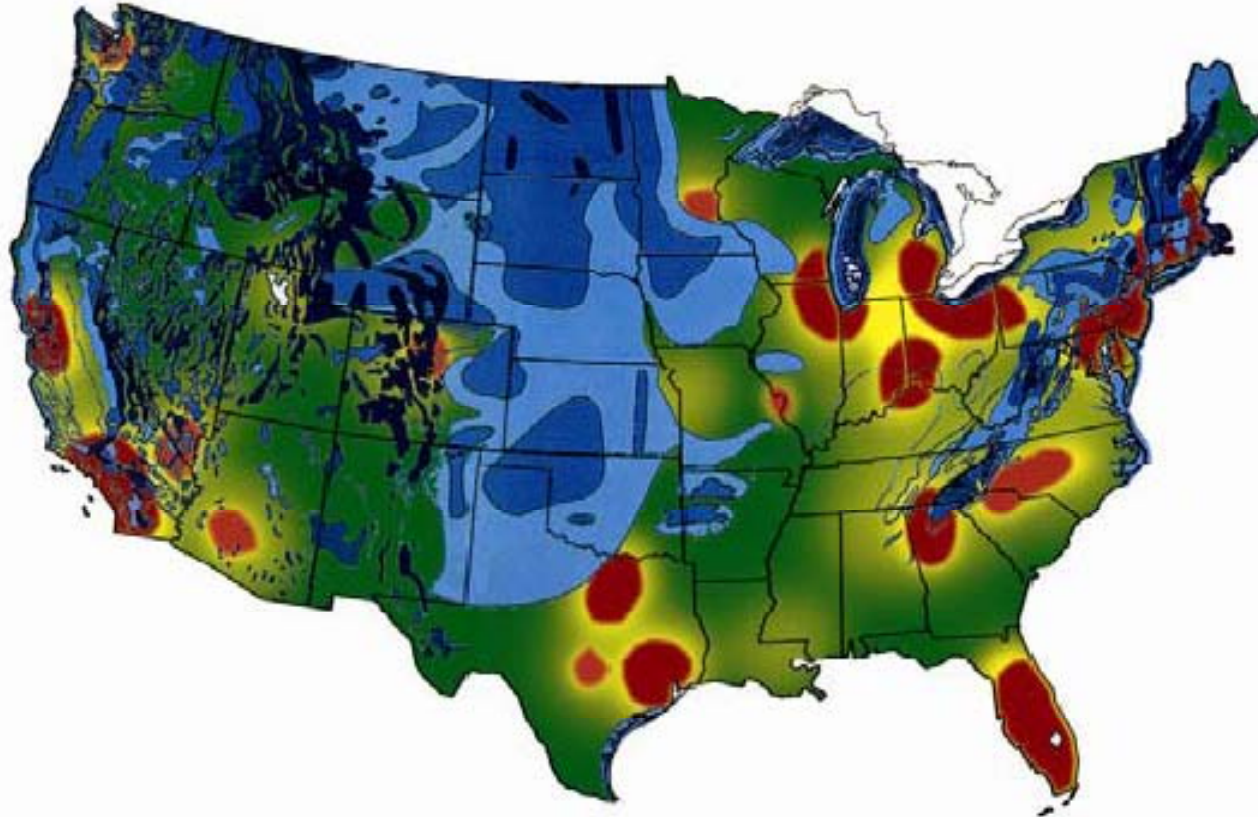


Figure B: Wind Availability and Demand Centers in the U.S.

Blue - high wind potential,
Brown - large demand centers, and
Green - little wind and smaller demand centers.

CONCLUSIONS

- There are many different components of an electric power grid
- There are many different types of smart grid investments
- The benefits of “smart grid” investments are diverse and have not been quantified very well
- The costs are substantial
- There are gainers and losers
- Institutional and regulatory barriers associated with the U.S. electric power industry are much more important than problems raising the necessary capital