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Electric Energy Security in the Domestic Theater

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N-NC Energy Security WG
June 2010

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Overview

- **Background**
 - Development of the Electric Grid
 - Physical Characteristics
 - Power Failures
 - DOD Focus
- **Engagement**
 - Partners
 - DOD and Electric Grid Security
- **Way Ahead**
 - Observations
 - Opportunities



Motivation

“Almost complete dependence of military installations on a fragile and vulnerable commercial power grid and other critical national infrastructure places critical military and Homeland defense missions at an unacceptably high risk of extended disruption.”

- Defense Science Board, February 2008



Objective – Electric Energy Security

1. Assured supply and availability of electrical energy.
2. Protect against unauthorized access affecting information, control, availability, and reliability of electric power.



Our Focus

USNORTHCOM's unique focus is DOD mission assurance in the homeland



The Situation



Defense Science
Board



Feb 08 - “Critical national security and homeland defense missions are at an unacceptably high risk of extended outage from failure of the electric grid.”

May 09 - “Aurora threat revealed the possibility that sophisticated hackers could seriously damage the grid by destroying mechanisms downstream from the initial point of attack.”



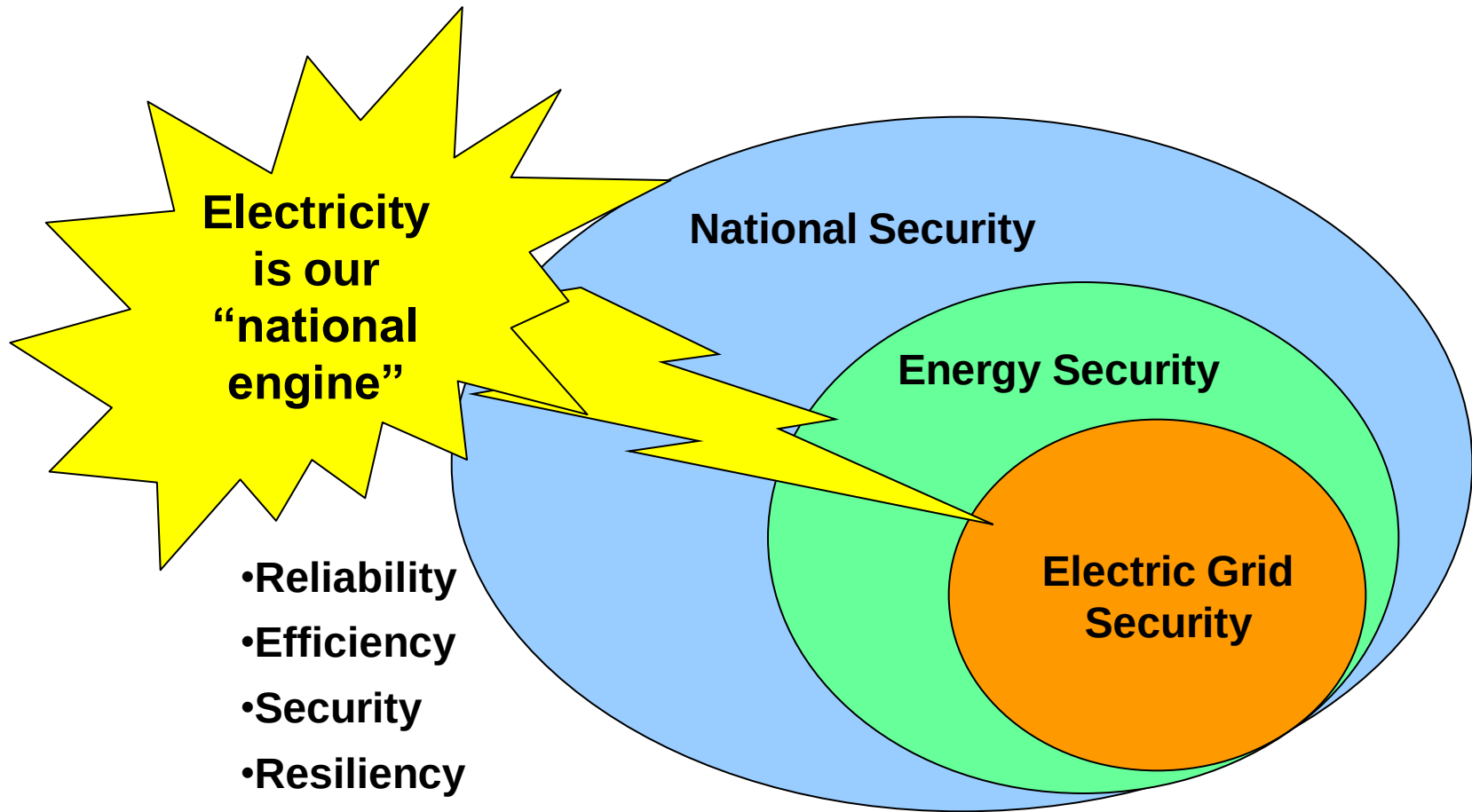
Feb 10 - “DoD will conduct a coordinated energy assessment, prioritize critical assets, and promote investments in energy efficiency to ensure that critical installations are adequately prepared for prolonged outages caused by natural disasters, accidents, or attacks.”

References:

- The Defense Science Board Task Force on DoD Energy Security, “More Fight – Less Fuel,” February 2008.
- Powering America’s Defense, Energy and the Risks to National Security, by the Center for Naval Analyses Military Advisory Board, May 2009
- Quadrennial Defense Review Report, February 2010



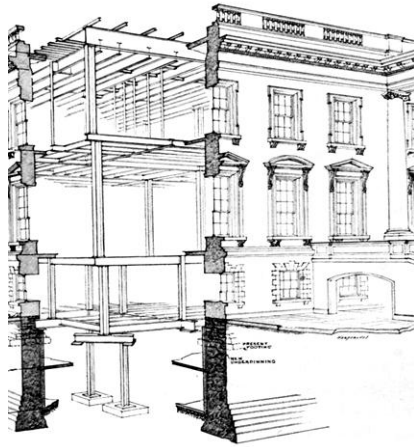
The National Engine



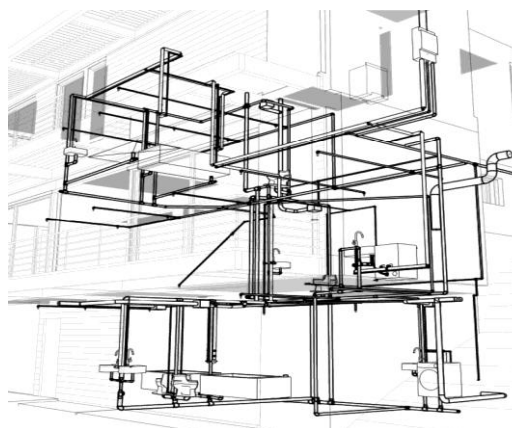


Electric Grid Development

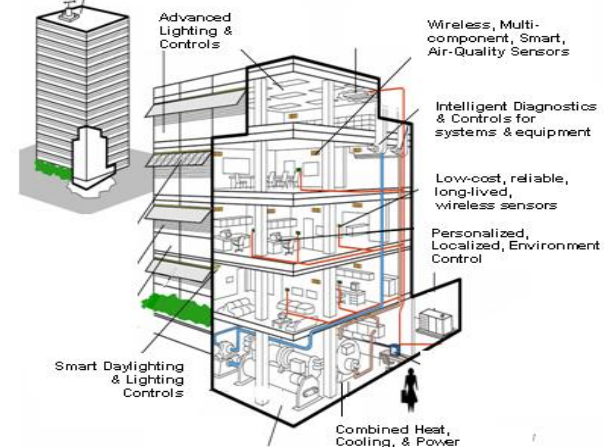
**Early Urban Utilities;
Like stand alone buildings**



**Grid interconnections to allow
power to flow between utilities**

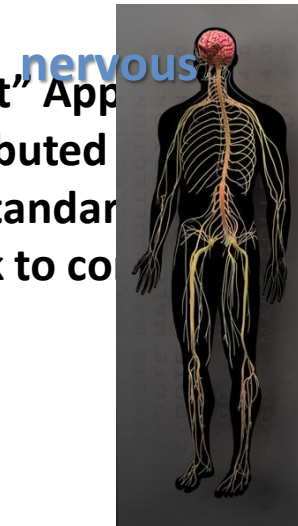
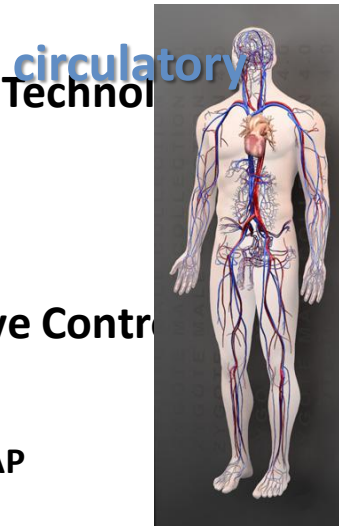


**Smart Grid adds in
comms & intelligence**



SMART GRID AS A 'HUMAN BODY'

- Digital Infrastructure and Controls Technology
- Dynamic Distribution
- Distributed Generation
- Renewable Integration
- Real Time Automated, Interactive Control Technology

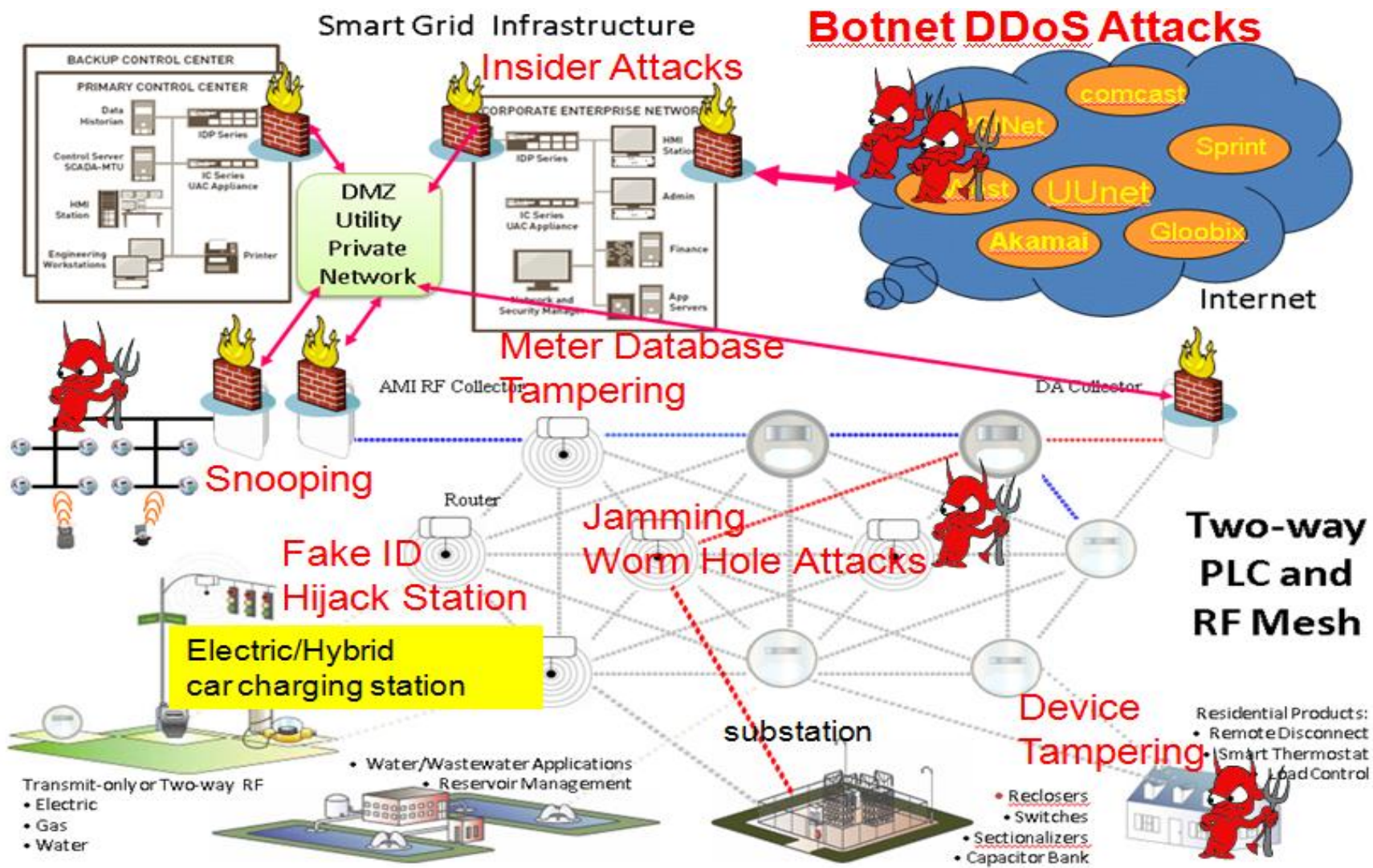


Source: Human body analogy: MIT and SAP
Smart Grid attributes: NIST

Integrate "Smart" Applications
Advanced Distributed
Infrastructure Standards
Rapidly feedback to control
options



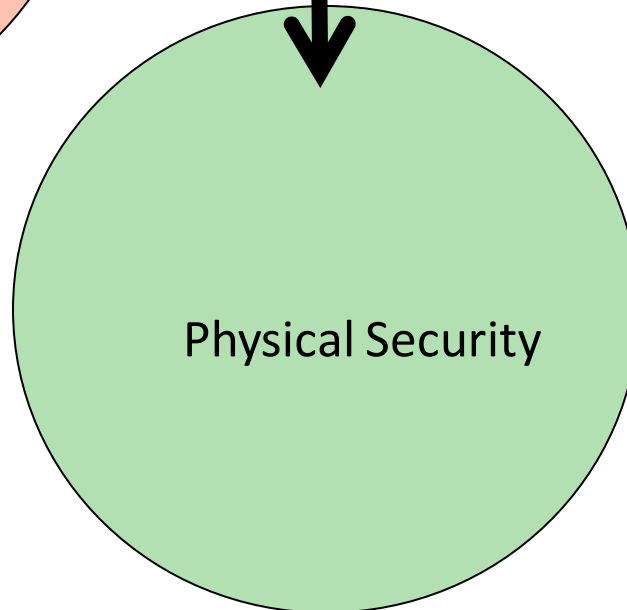
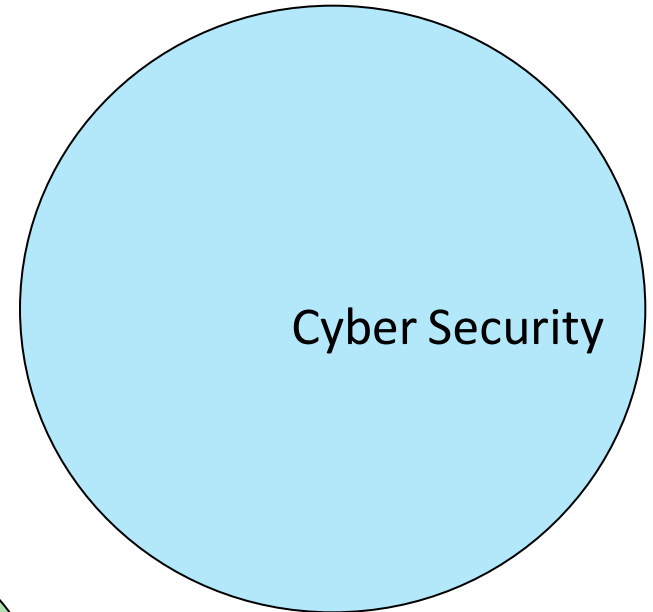
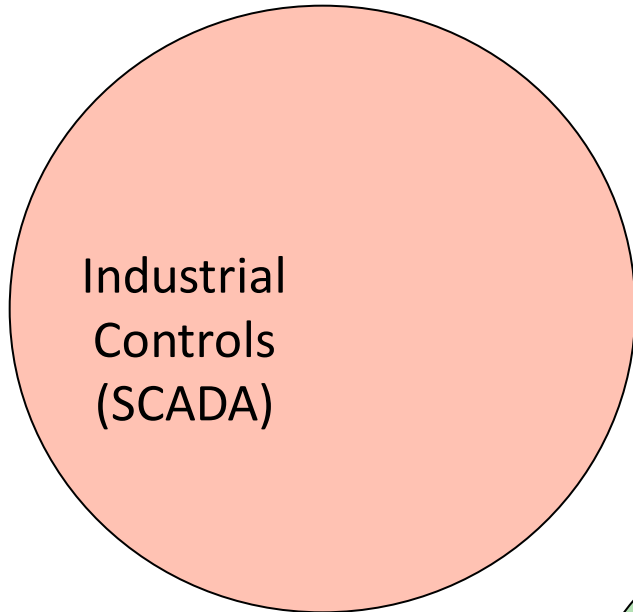
Smart Grid Cyber Vulnerabilities





Gap in Expertise

Electric Grid Security





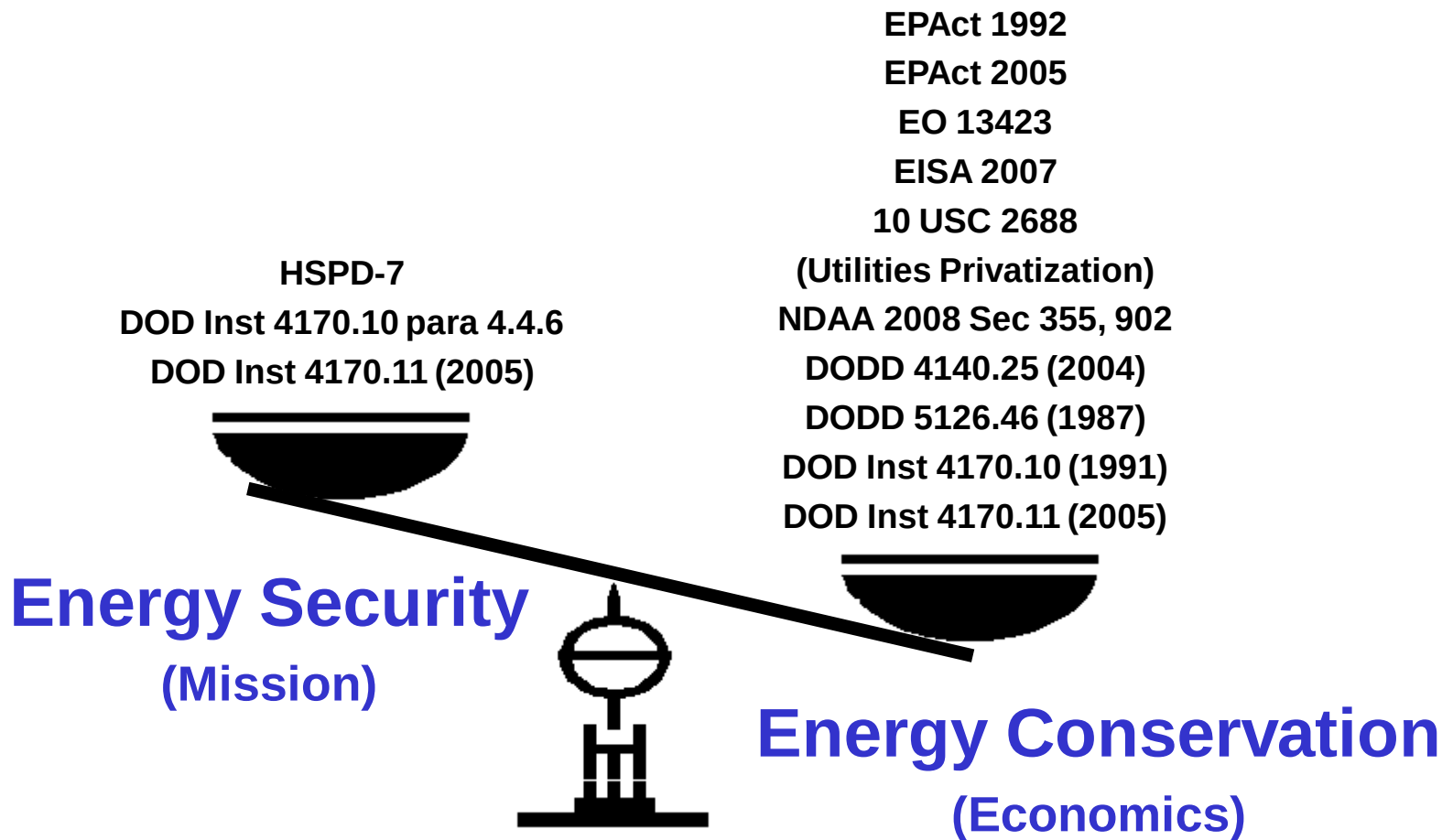
Northeast Blackout of 2003

- 14 August 2003 starting at 3:41 PM EDT
- 55 Million People
- New York, New Jersey, Maryland, Connecticut, Ohio, Michigan, Pennsylvania, Ontario and parts of Massachusetts
- Approx 48 Hours
- Cause:
 - Overgrown tree branches near Eastlake, Ohio impacted High Voltage lines during high power demand period.





Legislative and Policy Focus





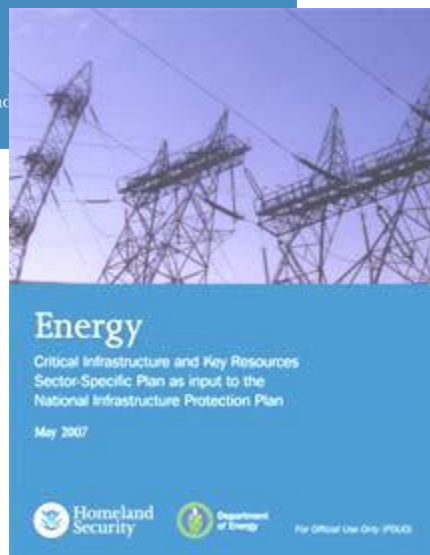
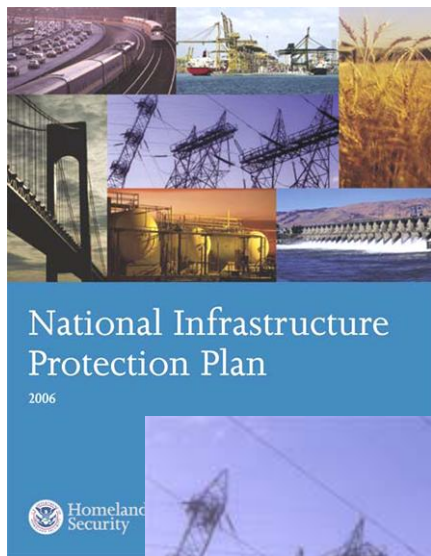
National Infrastructure Protection Plan (NIPP)

NIPP

- Unifies effort for protection of critical infrastructure and key resources

Energy Sector Specific Plan

- Collaborative process between the private sector, state, local, and tribal governments,
- Identify threats, mitigate vulnerabilities, minimize consequences





Regulatory Bodies

Government

- **Federal Energy Regulatory Commission**
- **State Public Utility Commissions**



Industry

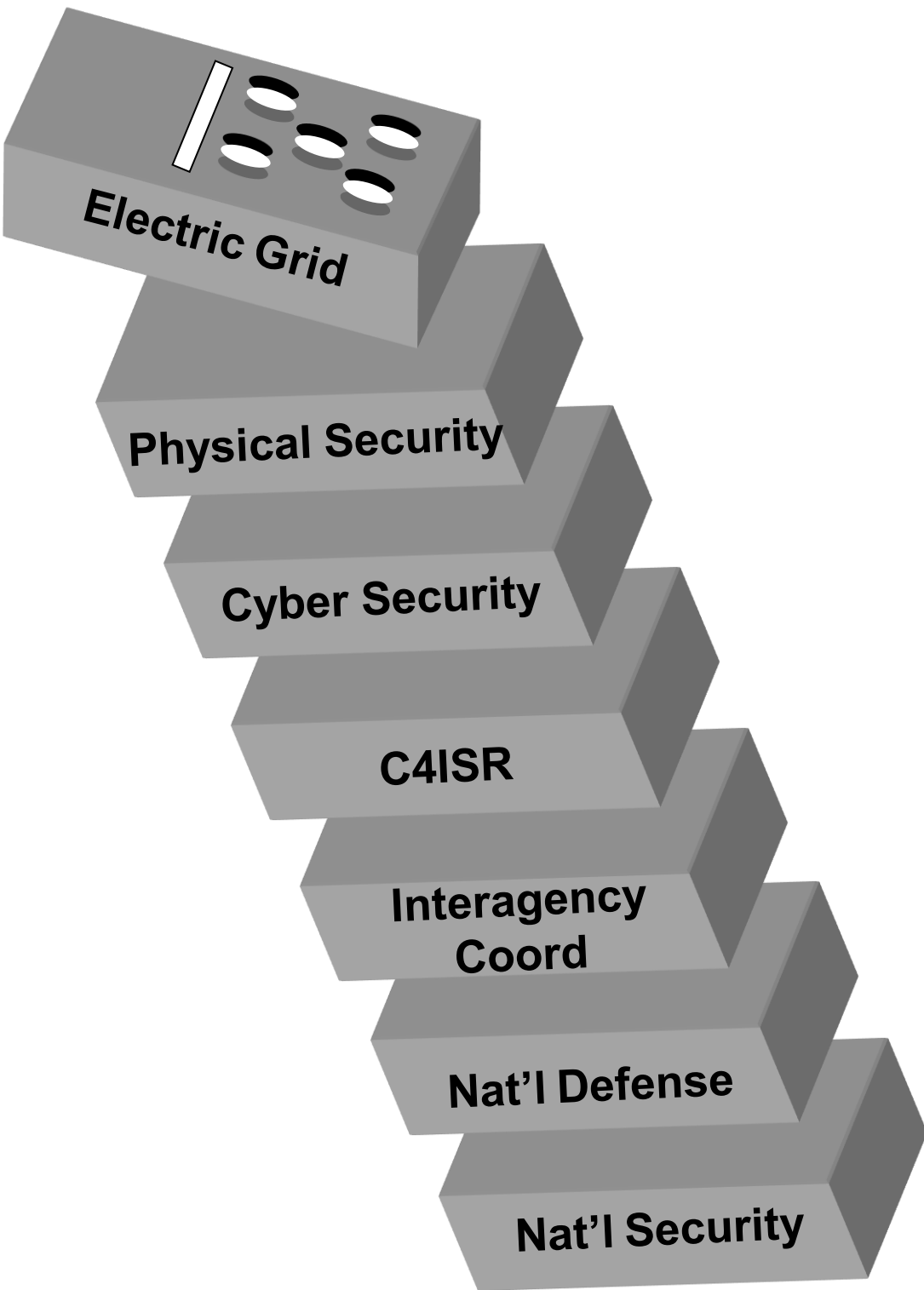
- **North American Electric Reliability Corporation (NERC)**
- **Electric Utility Associations**
 - **Edison Electric Institute (EEI)**
 - **American Public Power Association (APPA)**
 - **National Rural Electric Coop Association**



Conclusions and the Way Ahead



Dependence on a Fragile Grid

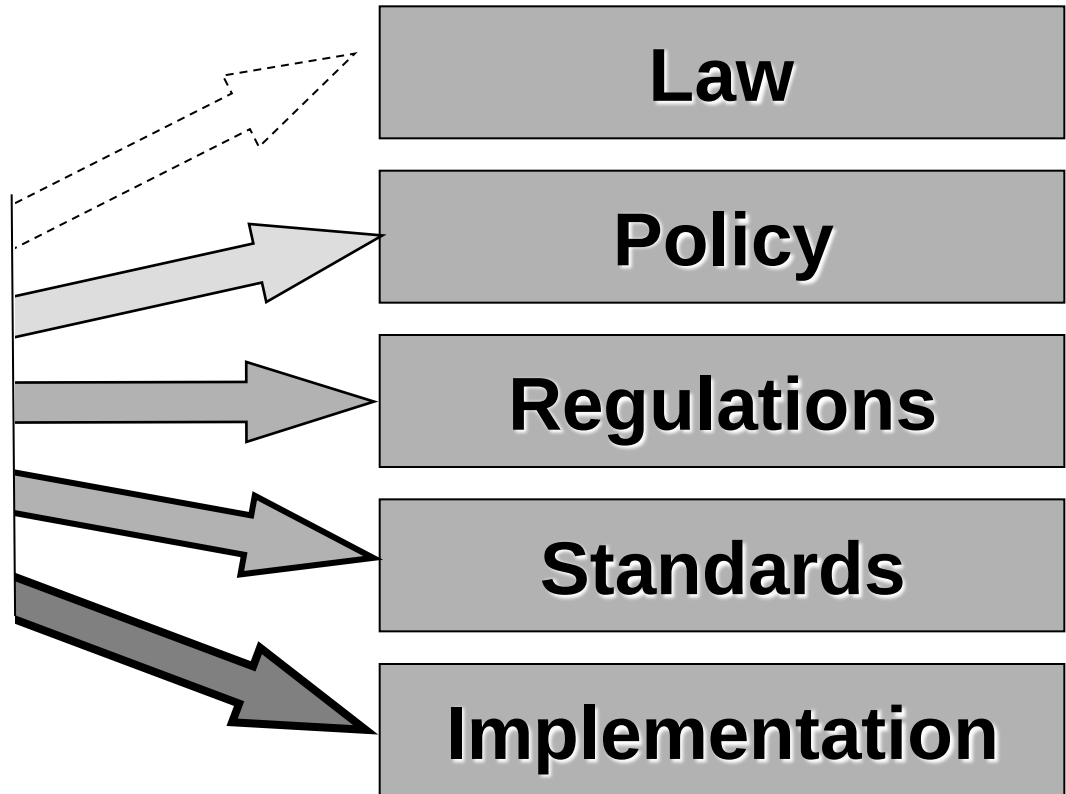




Scope of Influence



Electric Grid Security





Way Ahead

- Partnership in national and community initiatives
 - Smart Grid Development
 - Influence Implementation of Smart Grid in CONUS
 - JCTD – Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS)
 - Rocky Mountain Secure Smart Grid Initiative (RMSSGI)
 - Renewable Energy development on military bases
- Table Top Exercise
 - Secure Grid '10
 - July 2010





What Is SPIDERS?

Reduce the “unacceptably high risk”* of extended electric grid outages by developing the capability to provide secure generation and distribution at an installations while maintaining operational surety & security

- ***Demonstrate:***
 - ***Cyber-security of electric grid***
 - ***Smart Grid Technologies & applications***
 - ***Islanded micro-grid***
 - ***Integration of distributed & intermittent renewable sources***
 - ***Demand-side management***
 - ***Redundant back-up power systems***
- ***Results in:***
 - ***First complete DoD installation with a secure, smart micro-grid capable of islanding***
 - ***Template for DoD-wide installation energy security***

**From Defense Science Board Task Force on DoD Energy Security, Feb 2008*



SPIDERS Participants

- **USPACOM, USNORTHCOM
DOE, and DHS**
- **DOE - 5 Nat'l Labs**
- **OSD Power Surety Task Force**
- **Military Services**
- **Navy Facilities Engineering Command**
- **States of Hawaii & Colorado**
- **Local Utility Companies**



Hawaiian Electric Company



Colorado Springs Utilities
It's how we're all connected



Themes and Messages

- **USNORTHCOM is a key partner within DOD advocating for a reliable, efficient, secure, and resilient electrical power grid.**
- **USNORTHCOM strongly encourages increased energy efficiency based on sound technical solutions *that fully consider security implications.***
- **The time to include security is now!**
 - **Industry is moving forward with Smart Grid implementation, with or without consideration of DOD security requirements**
 - **Better to design in security now than to patch later**





BACK UP SLIDES



History of Early Electric Grid

Year	Event	Comments
1882	Edison Pearl Street Generating Station, New York City	59 Customers
1896	Niagara Falls Hydroelectric Plant, Westinghouse	First AC transmission to remote customers
1920	Federal Power Commission (FPC) created by Congress	Coordinate Hydroelectric projects under Federal control; ad-hoc staff from other Federal agencies
1930	Federal Power Act	Established five bi-partisan commissioners
1901-1932	Electrification of urban America	
1930-1945	Electrification of rural America	Funded through USDA stimulus funds
1935	Public Utility Holding Company Act (PUHCA)	Beginning of regional electric monopolies
1935	Federal Power Act	Gave regulatory authority to states; FPC regulated bulk power transmission across state lines

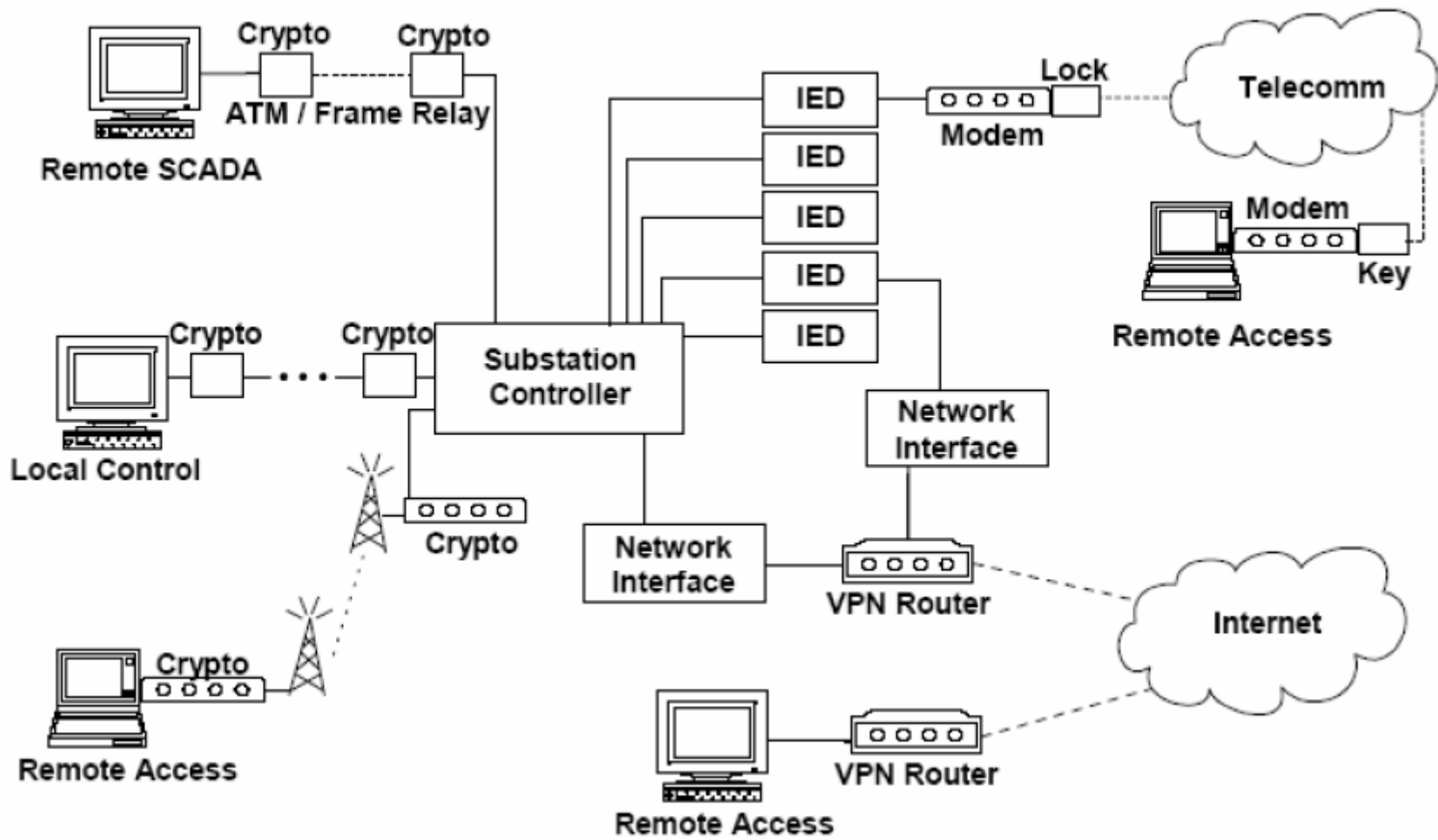


History of Electric Grid

Year	Event	Comments
1965	Northeastern power blackout	Raised concerns about reliability of large interdependent power networks
1967	Electric Reliability Act	Drove establishment of electric performance standards
1968	North American Electric Reliability Council (NERC) created	Industry created non-profit self-regulating organization.
1977	Federal Power Commission (FPC) reorganized as Federal Energy Regulatory Commission (FERC)	
1978	Public Utility Regulatory Policies Act (PURPA)	Set the stage for deregulation and Independent Power Producers (IPP)
1979	Three Mile Island	Shut down nuclear plant construction
1992	Energy Policy Act (EPACT)	Bulk power transmission deregulation
2005	Energy Policy Act (EPACT)	Gave FERC punitive authority to enforce reliability standards
2007	Energy Independence & Security Act (EISA)	National grid integration and Renewable Energy initiatives
2008	FERC established 8 mandatory reliability standards	

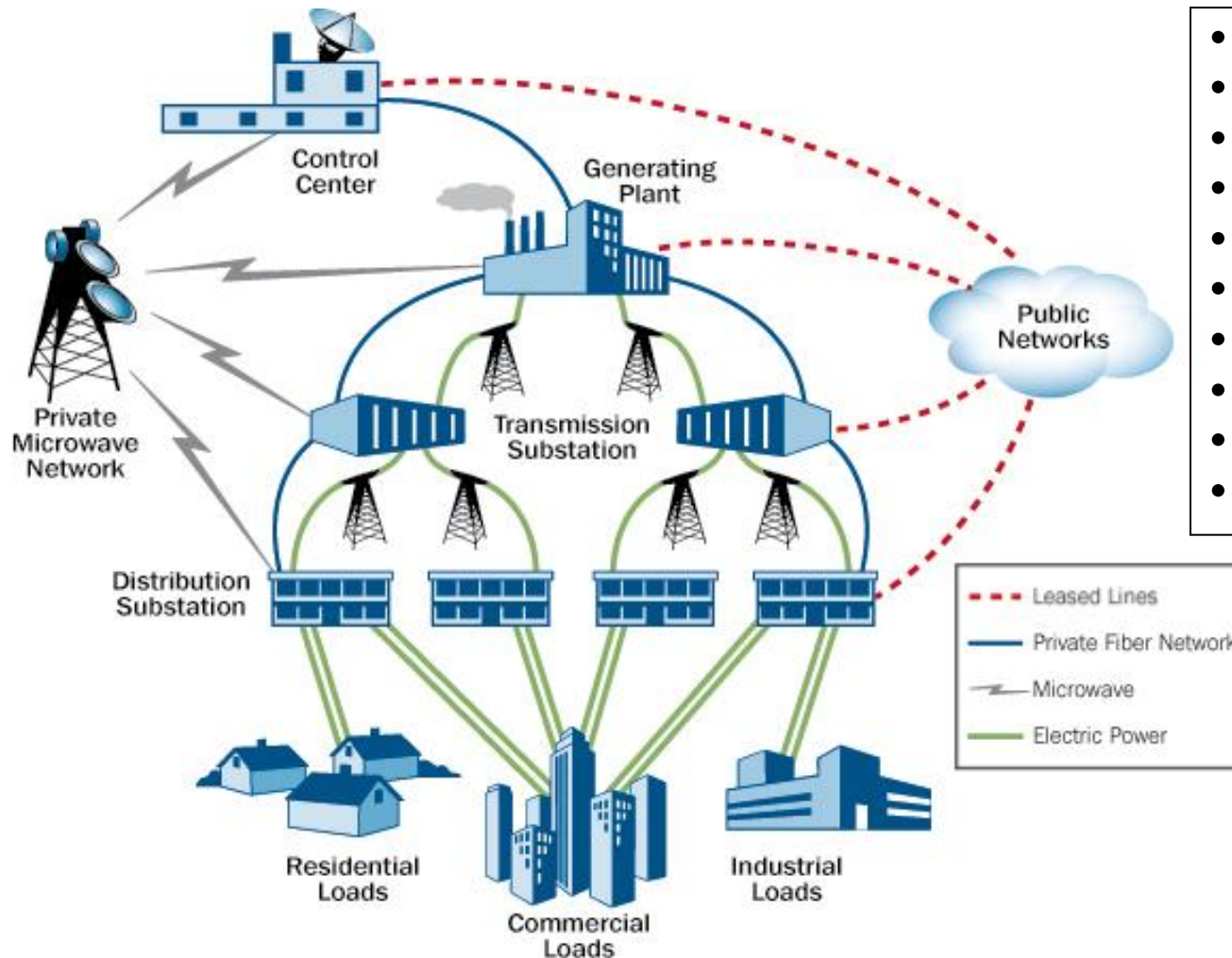


Electric Utility Control Systems





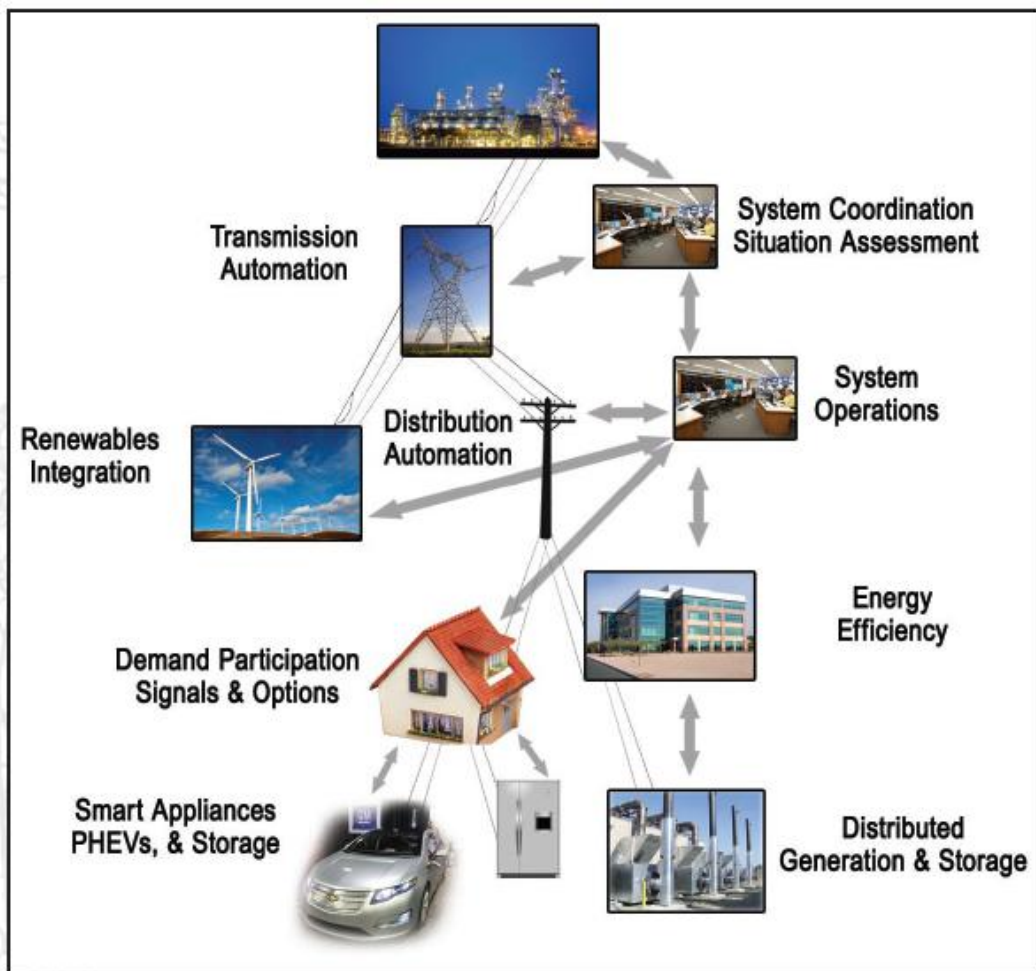
Today's Electric Grid



- **Centralized**
- **One-way power flow**
- **Regulated Monopoly**
- **Generation**
- **Distribution**
- **Inflexible demand**
- **Aging Infrastructure**
- **Manual operations**
- **Increasing renewables**
- **Lacks interoperability**



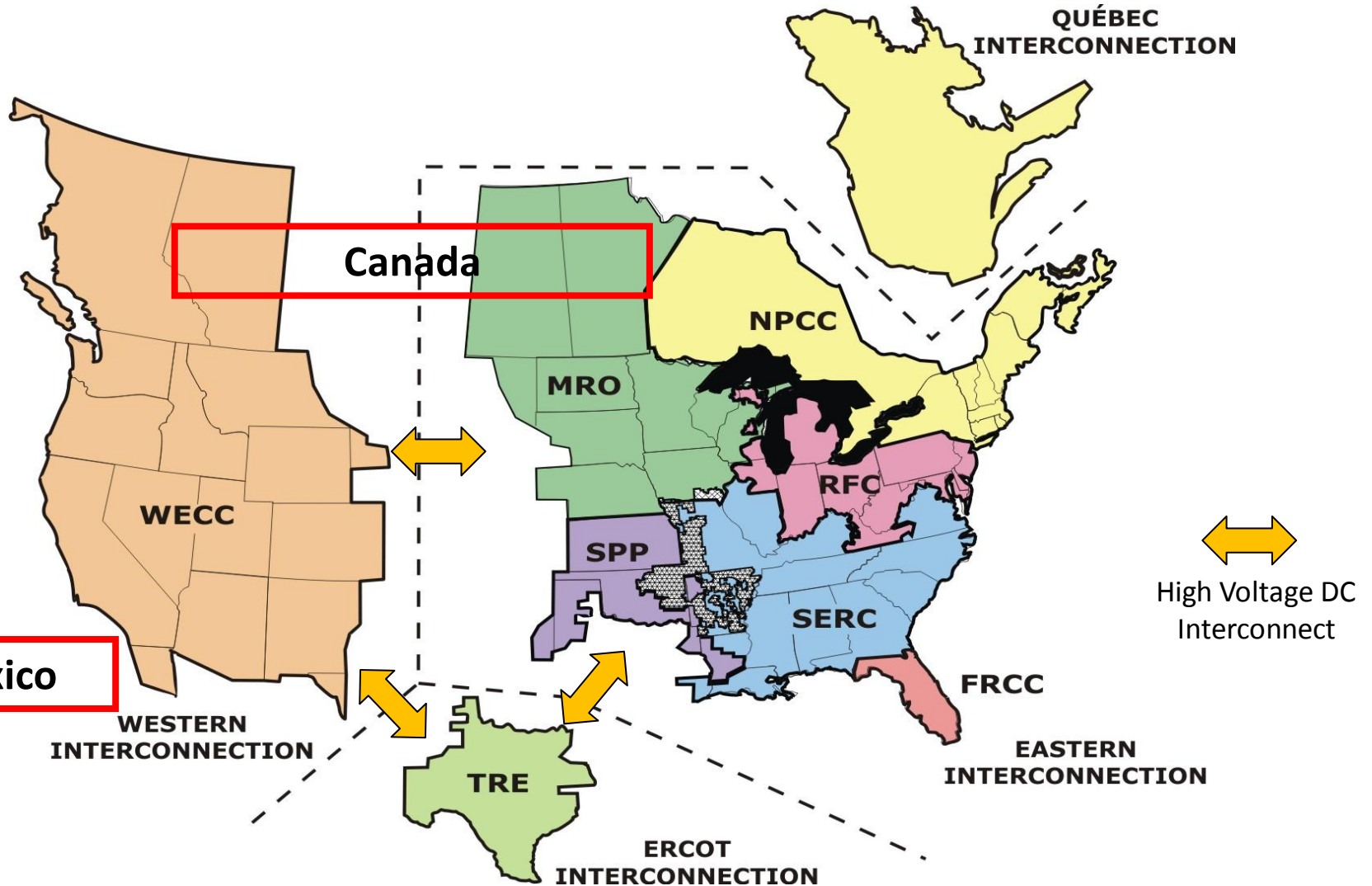
The Smart Grid



- Digital Information and Controls Technology
- Dynamic Optimization
- Distributed Generation
- Renewables Integration
- Real Time, Automated, Interactive Control Technology
- Integrate “Smart” Appliances
- Advanced Distributed Storage
- Infrastructure Standards
- Timely feedback to consumers
- Control options



Electric Grid Regions and Interconnects





Electric Energy Initiatives

- **Advanced Metering Initiative**
- **Renewable Energy**
- **Smart Grid**



Wind Turbines at F.E. Warren AFB, WY



Solar Array at Fort Carson, CO



Electric Grid Security Objectives

- Ensuring proper access control to the smart grid network and role-based access control to its operations
- Protecting physical access to the smart grid network and devices
- Protecting individual smart grid components from exploitation
- Maintaining functionality during adverse conditions
- Restoring systems and services after an incident



Existing Standards for Smart Grid Interoperability

Standard	Application	Smart Grid Area
AMI-SEC System Security Requirements	Advanced metering infrastructure (AMI) and Smart Grid end-to-end security	IT
ANSI C12.19/MC1219	Revenue metering information model	IT
BACnet ANSI ASHRAE 135 - 2008/ISO 16484 -5	Building automation	COM
DNP3	Substation and feeder device automation	COM
IEC 60870 -6 / TASE.2	Inter-control center communications	COM
IEC 61850	Substation automation and protection	COM
IEC 61968/61970	Application level energy management system interfaces	
IEC 62351 Parts 1 -8	Information security for power system control operations	COM
IEEE C37.118	Phasor measurement unit (PMU)communications	COM
IEEE 1547	Physical and electrical interconnections between utility and distributed generation (DG)	POWER
IEEE 1686 -2007	Security for intelligent electronic devices (IEDs)	
NERC CIP 002 -009	Cyber security standards for the bulk power system	COM
NIST Special Publication (SP) 800 - 53, NIST SP 800 -82	Cyber security standards and guidelines for federal information systems, including those for the bulk power system	COM
Open Automated Demand Response (Open ADR)	Price responsive and direct load control	
OpenHAN	Home Area Network device communication, measurement, and control	
ZigBee/HomePlug Smart Energy Profile	Home Area Network (HAN) Device Communications and Information Model	



High Voltage Interconnects

About This Map »

EXISTING LINES

- 345-499 kV ?
- 500-699 kV ?
- 700-799 kV ?
- 1,000 kV (DC) ?

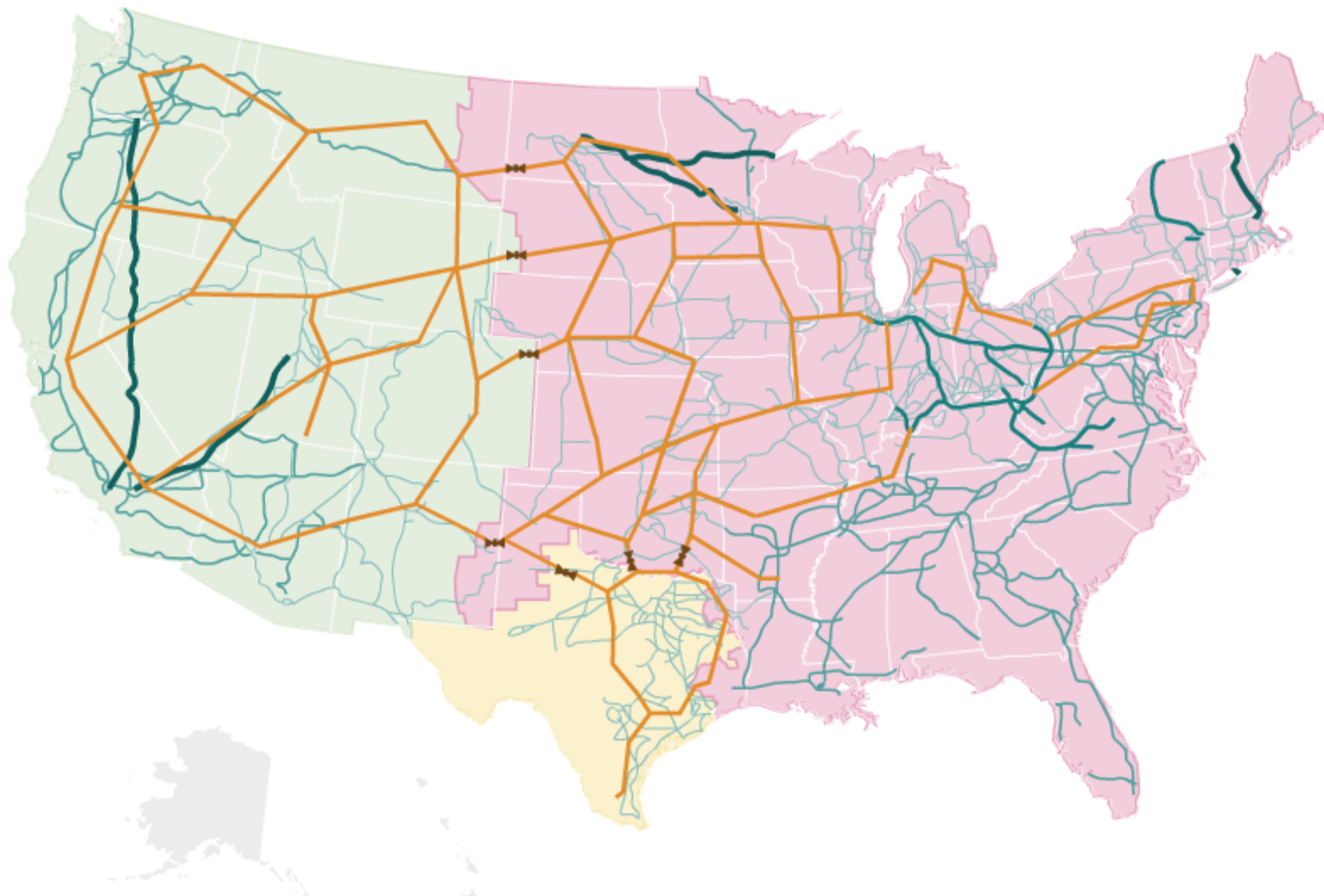
PROPOSED LINES

- New 765 kV ?
- AC-DC-AC Links ?

INTERCONNECTIONS

Major sectors of the U.S. electrical grid

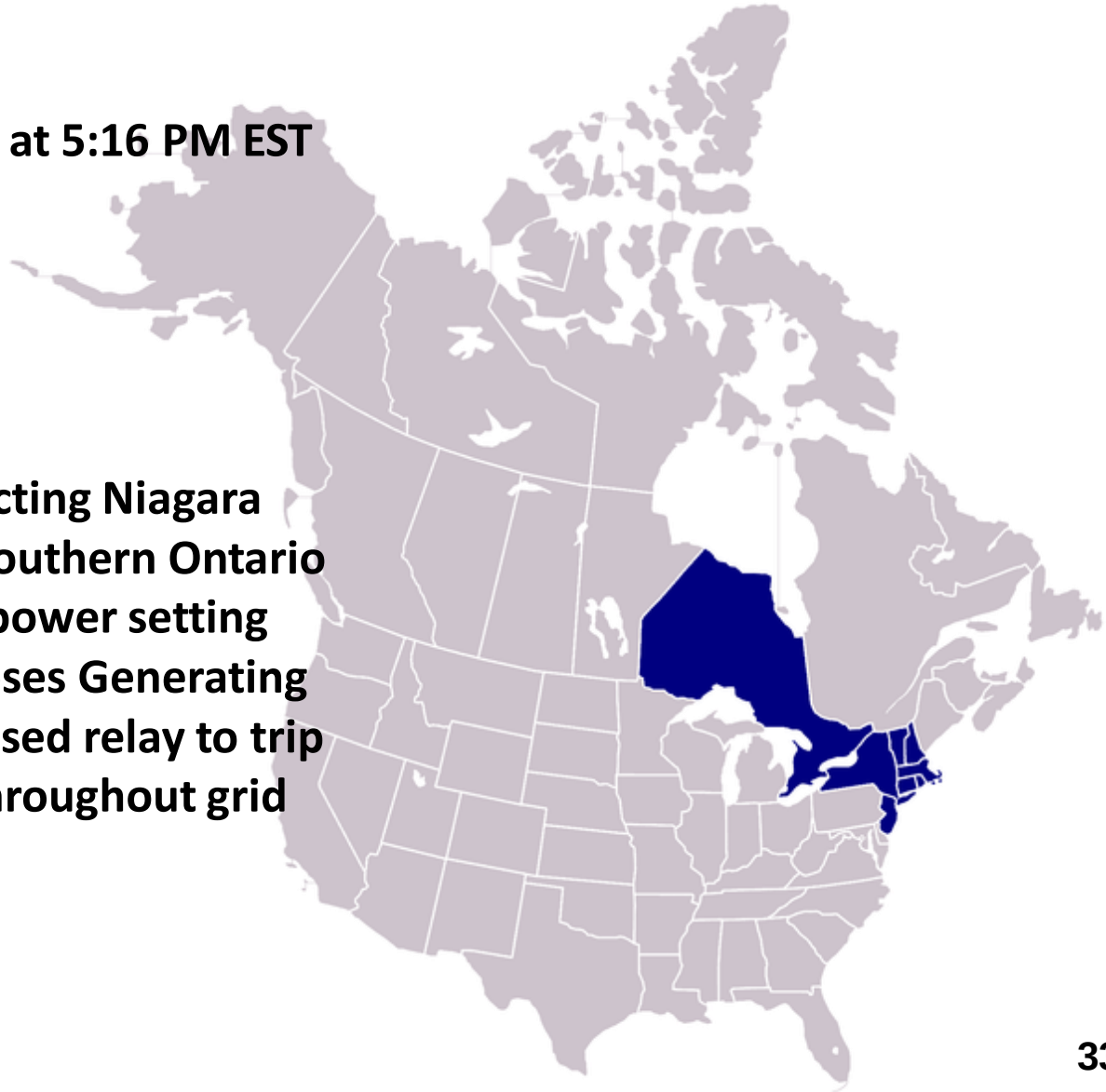
- Eastern
- Western
- Texas (ERCOT)





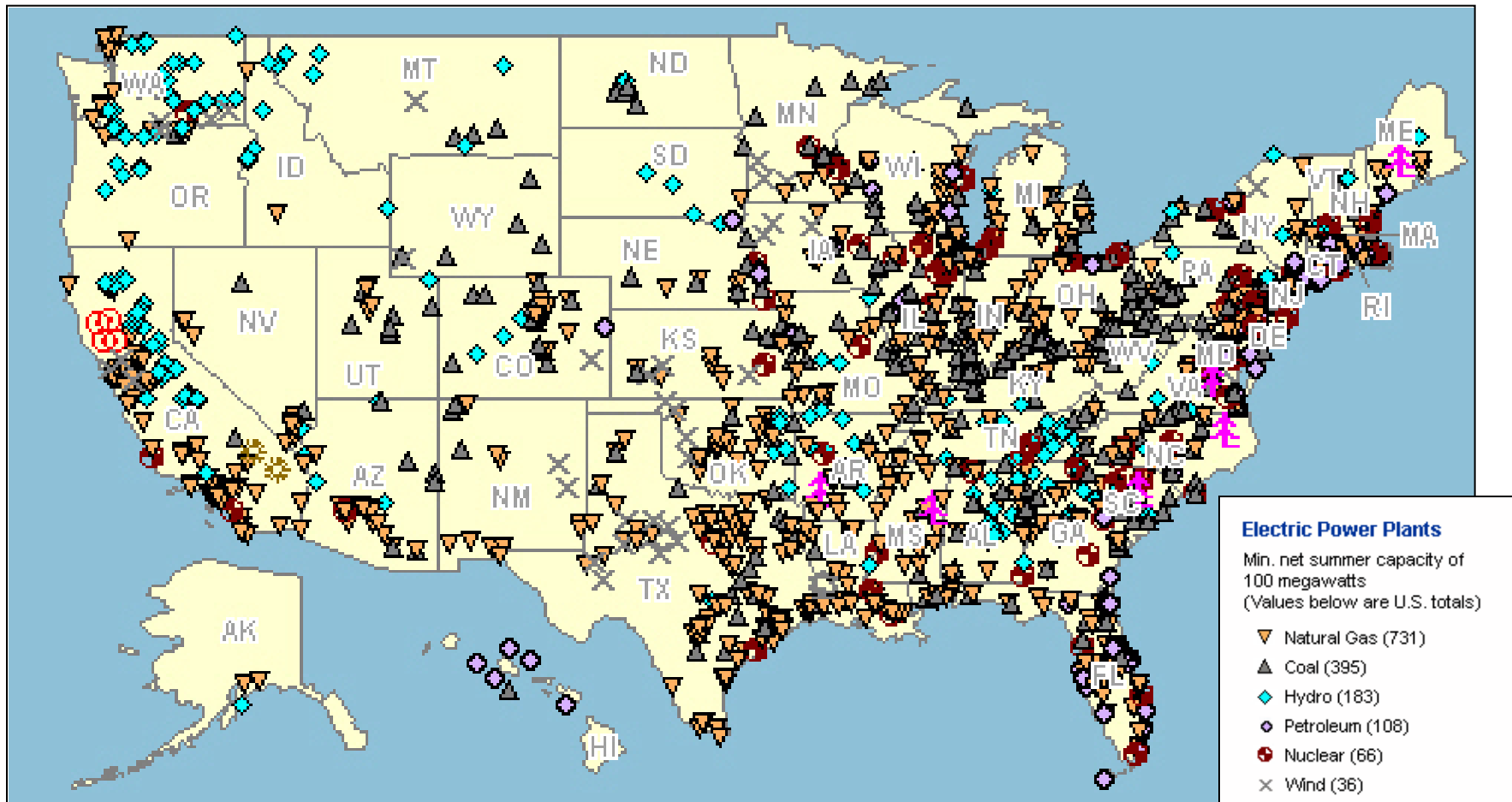
Northeast Blackout of 1965

- 9 November 1965 starting at 5:16 PM EST
- 25 Million People
- 80,000 Square Miles
- 12 Hours
- Cause:
 - Protective relay connecting Niagara Falls hydro plant with Southern Ontario
 - Relay set too low of a power setting
 - Surge from Robert Moses Generating Plant, Lewiston, NY, caused relay to trip
 - Cascading overloads throughout grid





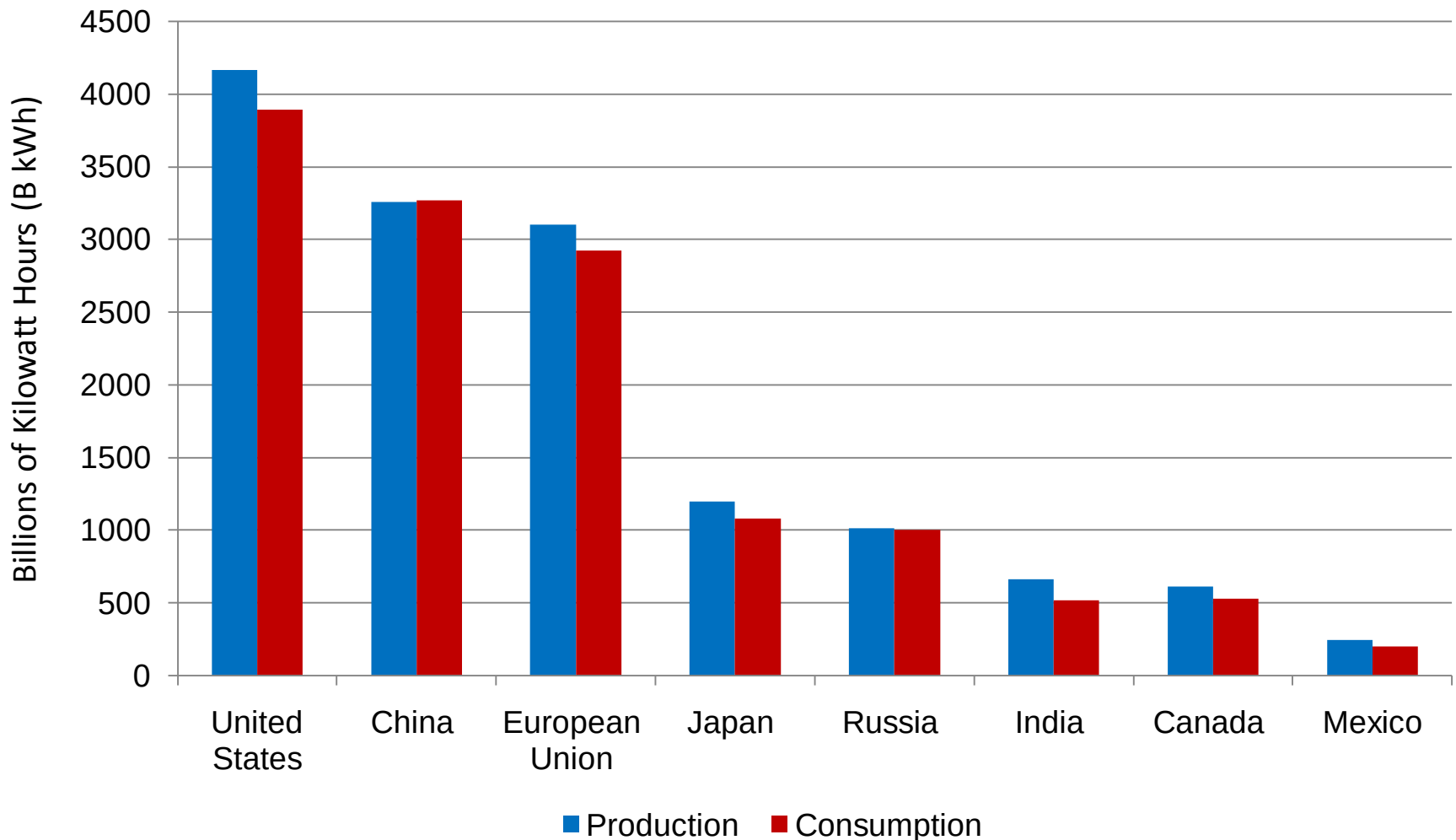
U. S. Electric Power Plants



Source: DOE Energy Information Administration, State Energy Profiles
<http://tonto.eia.doe.gov/state/>



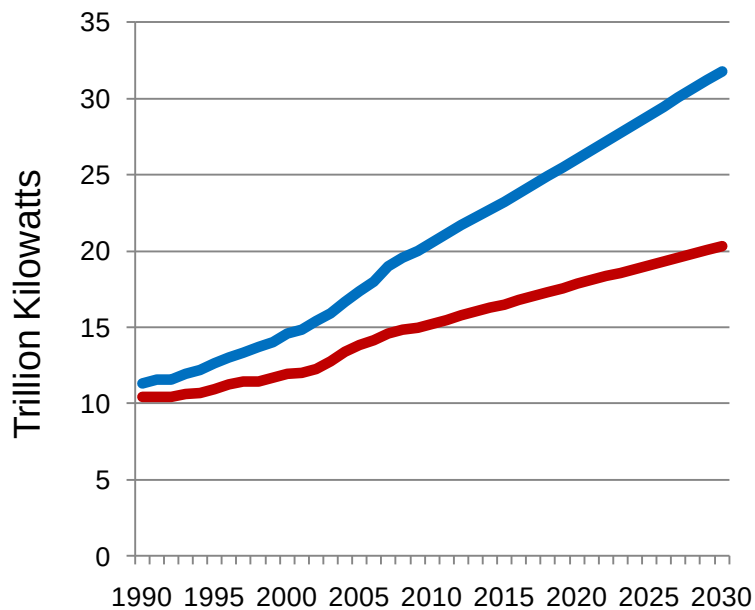
Comparison of World Electric Production and Consumption





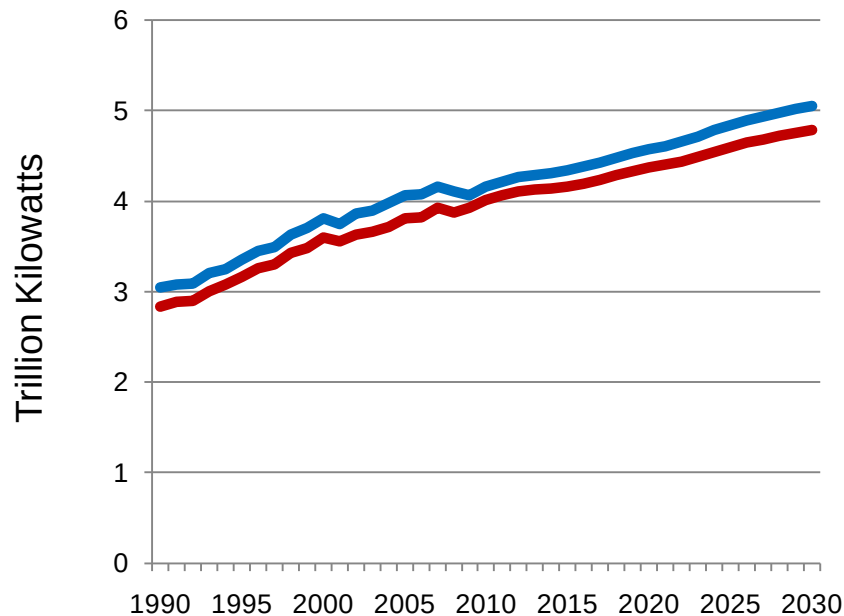
Relative Growth in Electric Generation and Consumption

World Electric Power



— Net Generation
— Net Consumption

US Electric Power

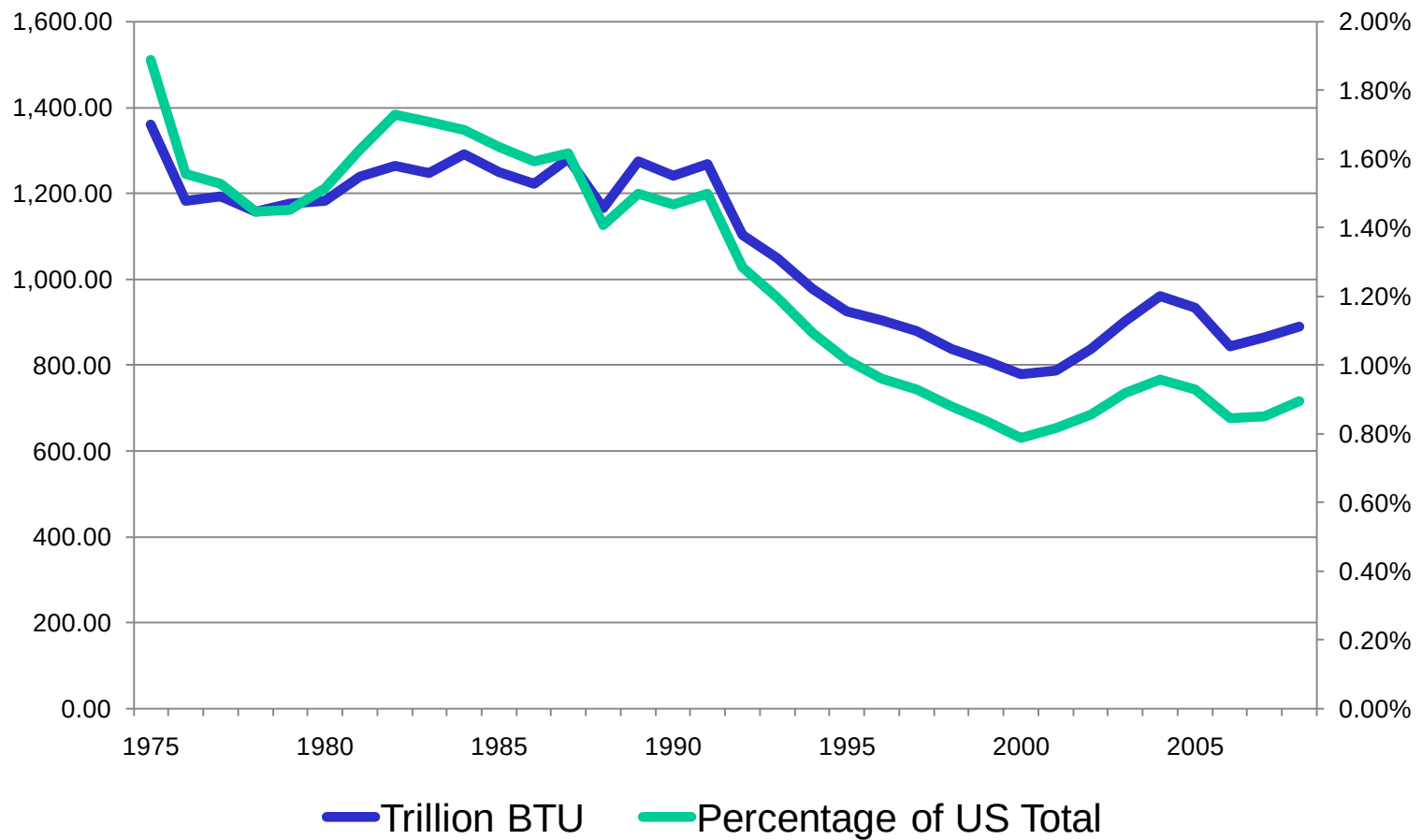


— Net Generation
— Net Consumption

Sources: DOE EIA International Energy Outlook 2009
DOE EIA International Generating Capacity, 1980-2006
DOE EIA International Electric Projections, 1990-2030



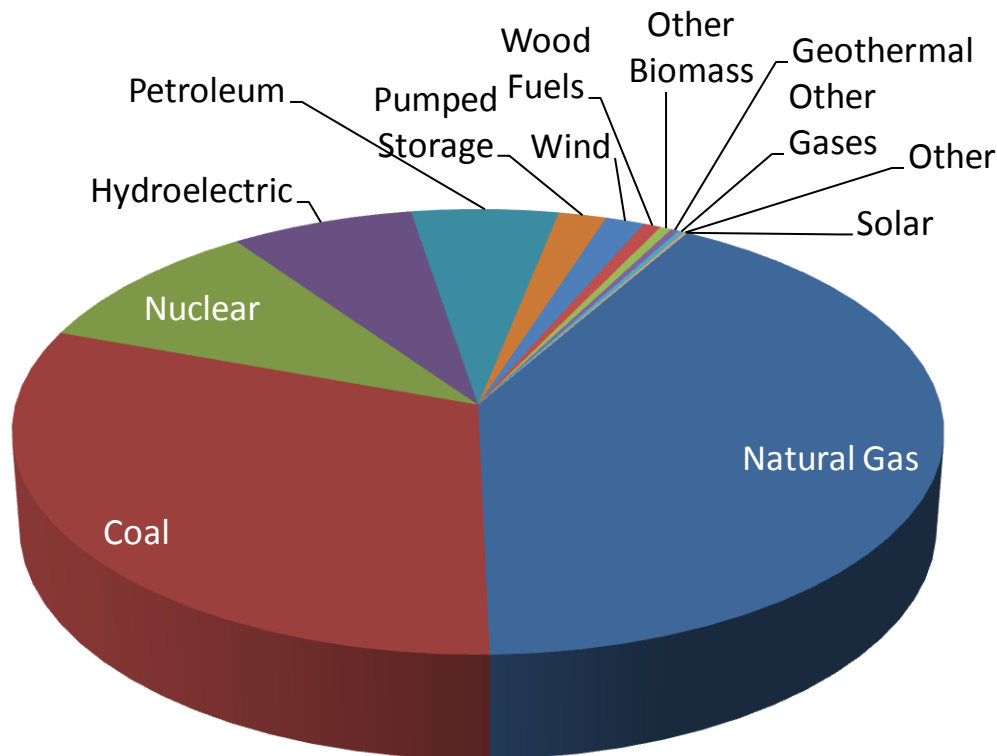
DOD Energy Consumption



Source: DOE EIA Annual Energy Review 2009



Electricity Production by Energy Source



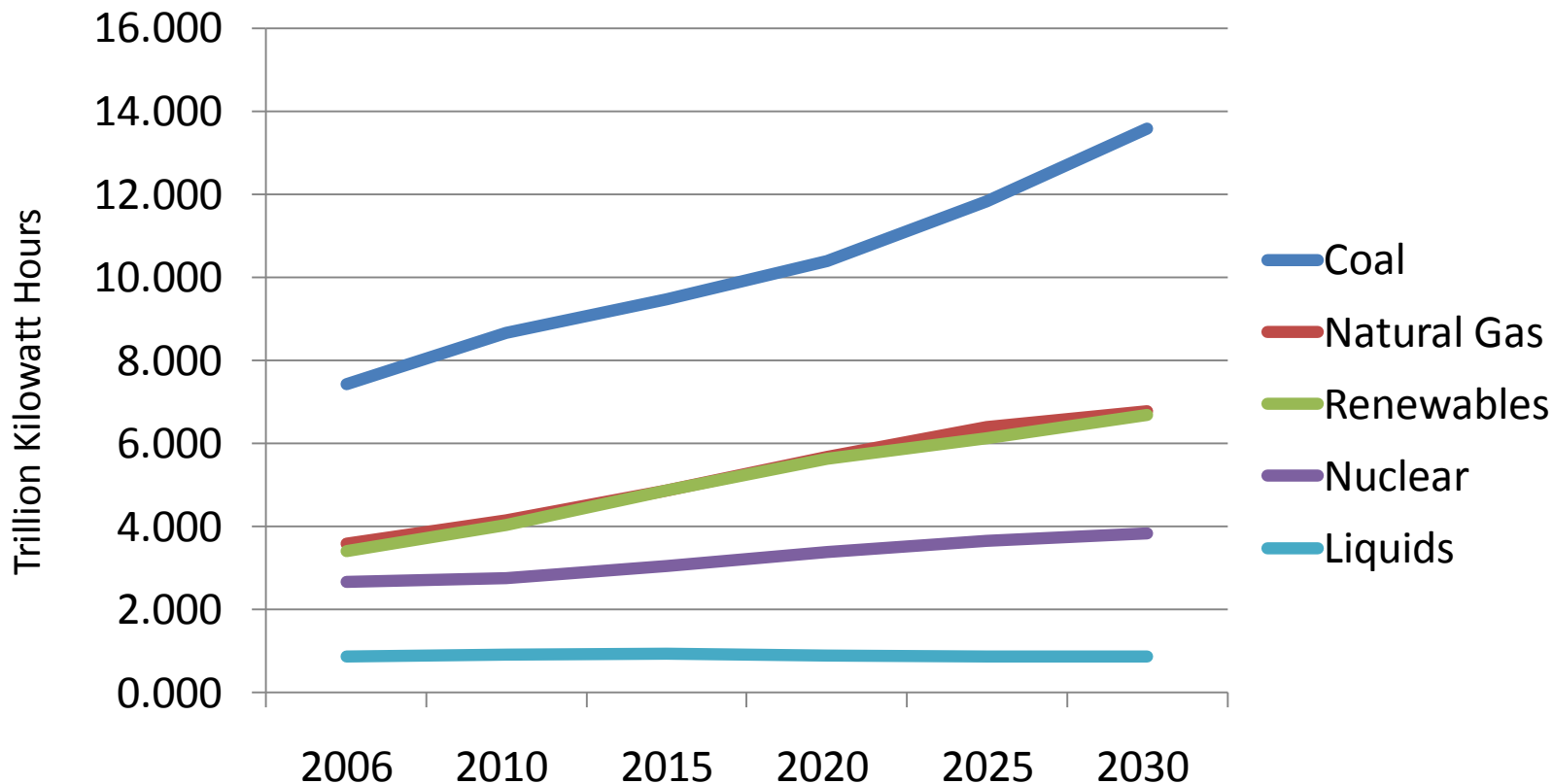
Energy Source	Capacity	Percentage
Natural Gas	449,389	41.31%
Coal	336,040	30.89%
Nuclear	105,764	9.72%
Hydroelectric	77,644	7.14%
Petroleum	62,394	5.74%
Pumped Storage	20,355	1.87%
Wind	16,596	1.53%
Wood Fuels	7,510	0.69%
Other Biomass	4,834	0.44%
Geothermal	3,233	0.30%
Other Gases	2,663	0.24%
Other	866	0.08%
Solar	503	0.05%
Total	1,087,791	100.00%

Source: DOE Energy Information Administration,
Electric Power Annual Report 2007 (Released 21 Jan 09)

Production Capacity In Megawatts (MW)



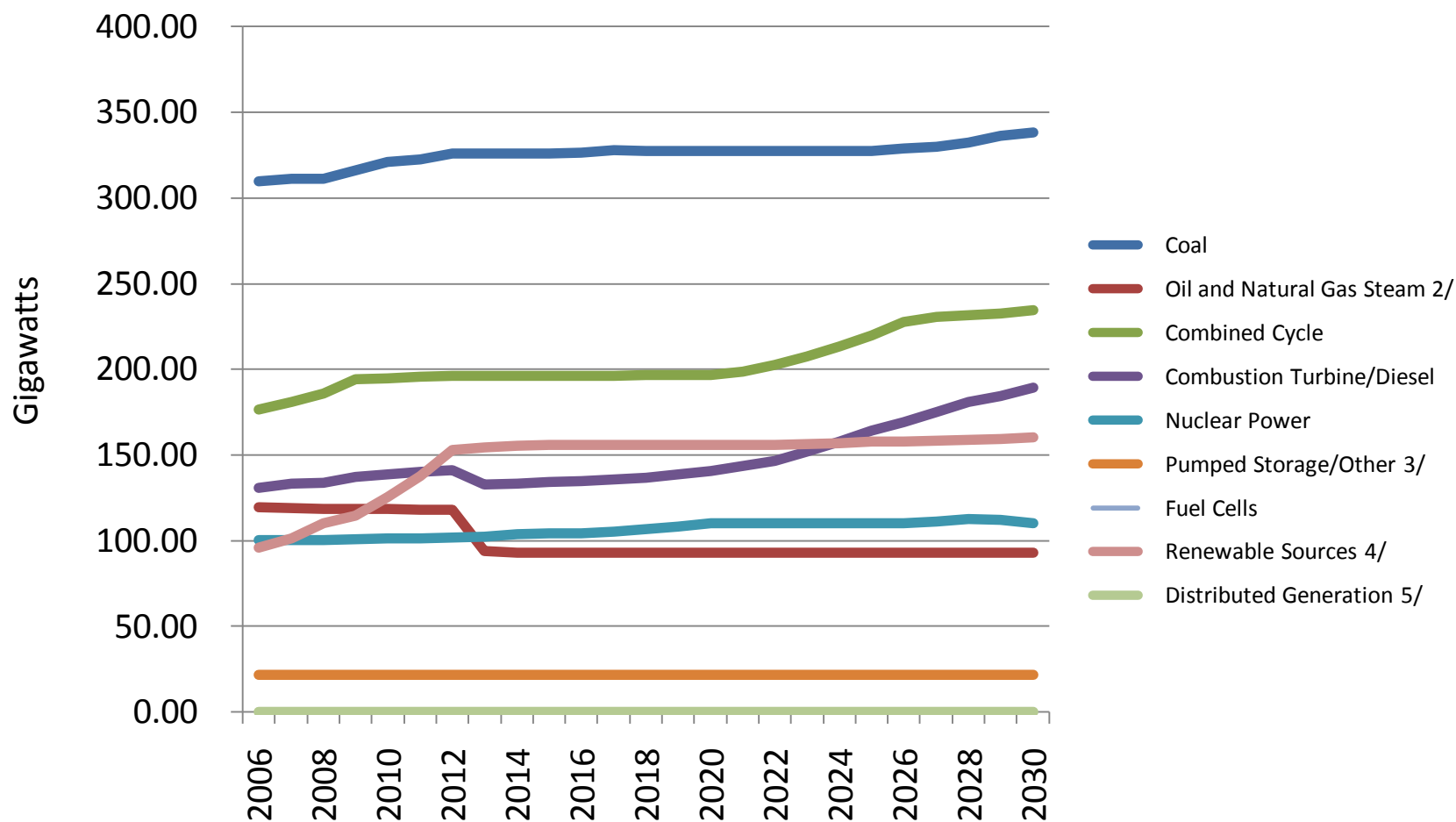
World Electric Generation Projections By Source



Source: DOE Energy Information Administration,
Report #:DOE/EIA-0484 (Released May 2009)

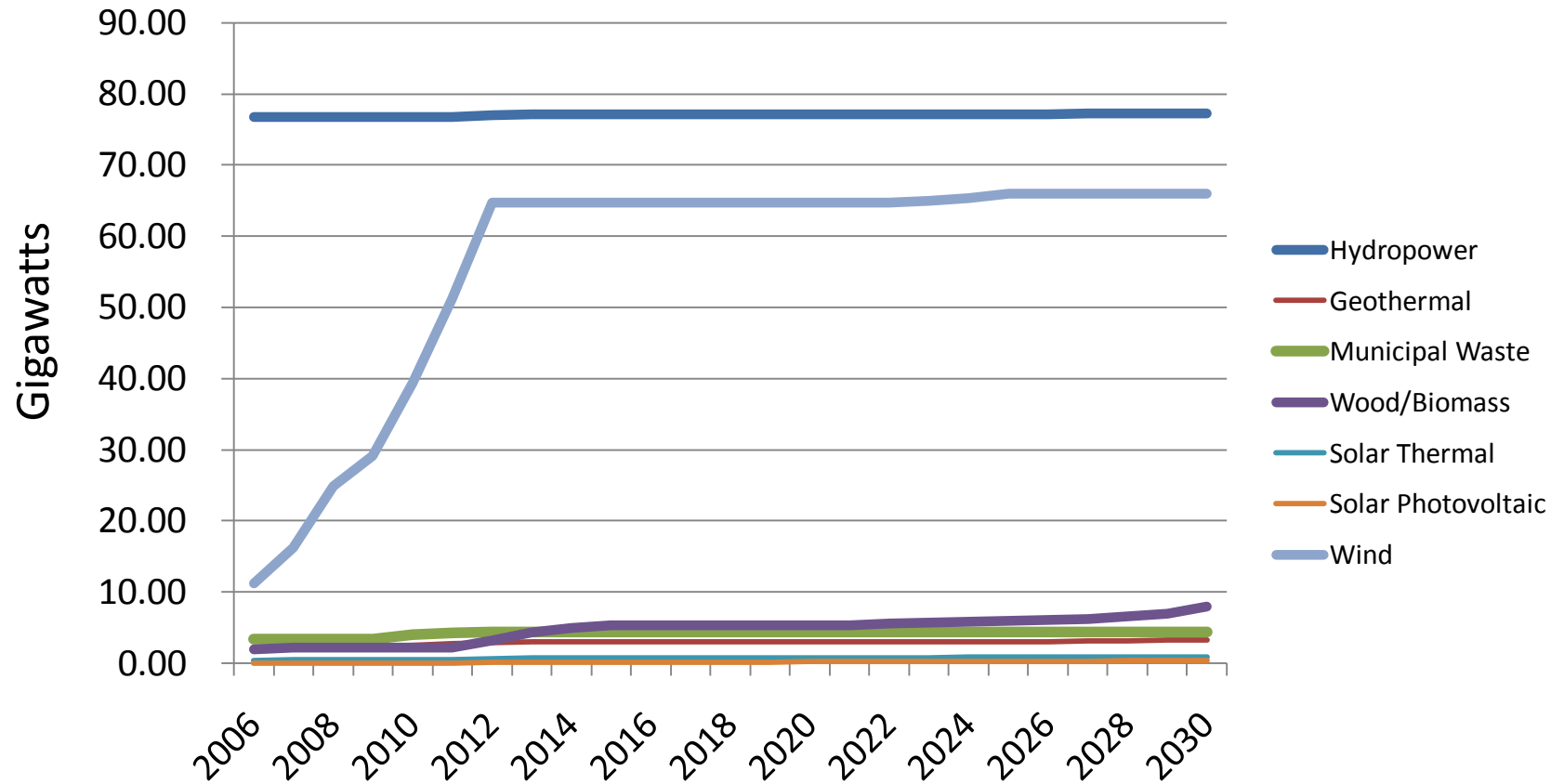


US Electric Generation Projections by Source



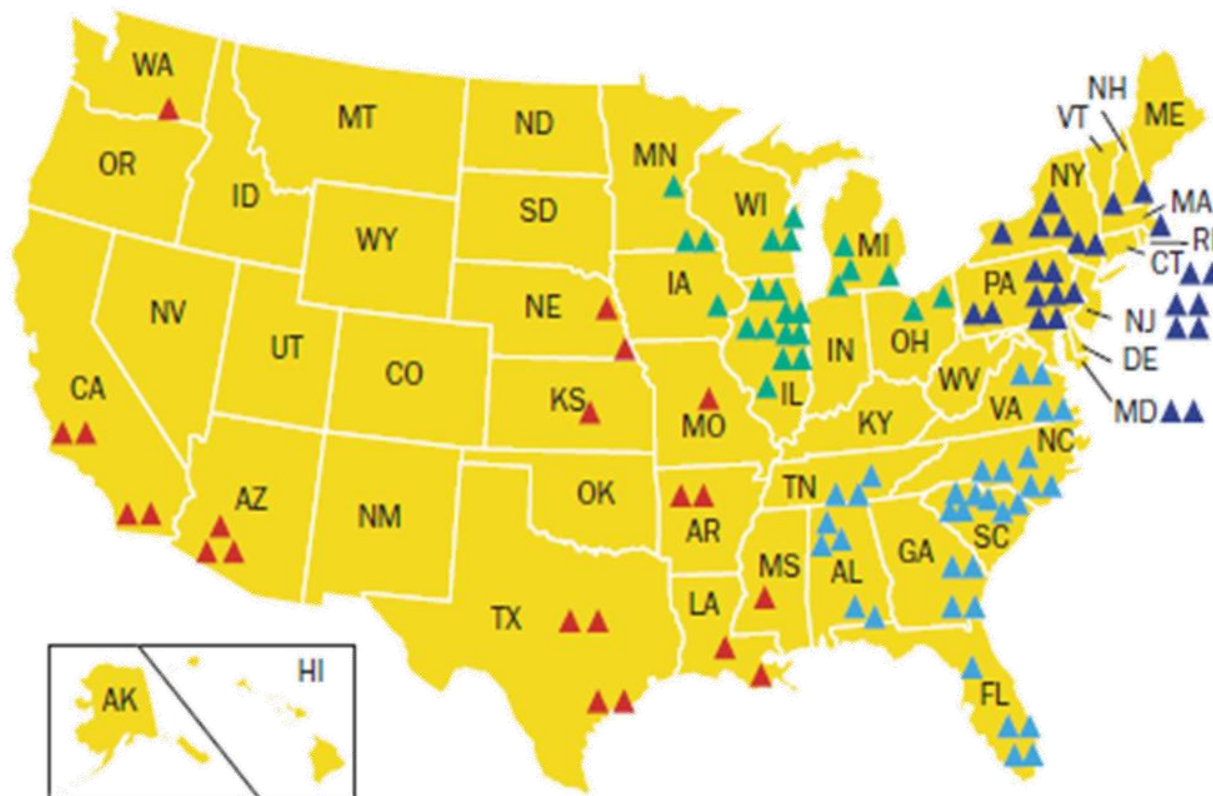


US Renewable Energy Projections





Operating Nuclear Power Reactors

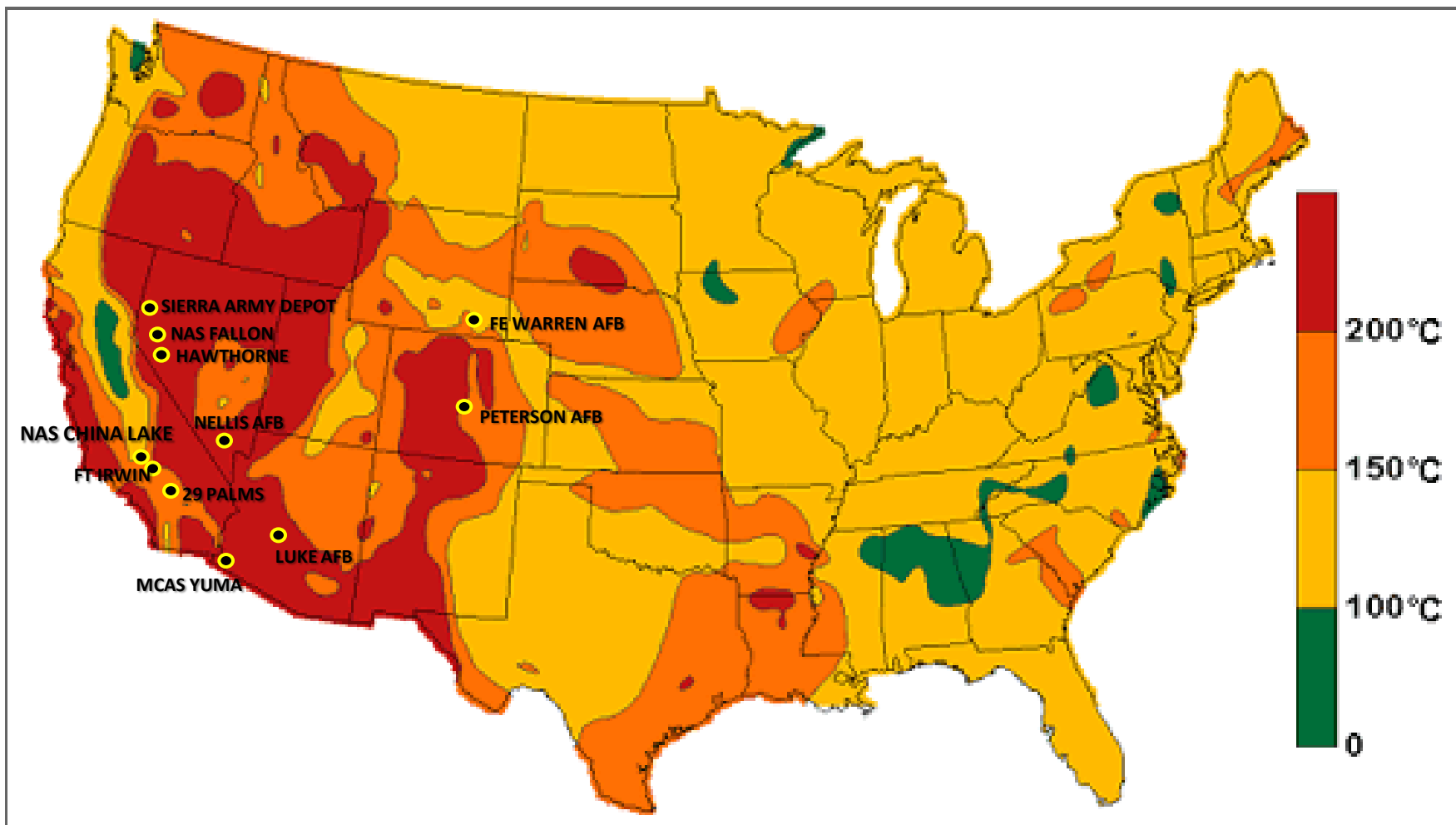


- **104 Reactors Licensed to operate in U.S.**
 - 32% of worldwide electric production by nuclear power
- **437 Operational Reactors Worldwide**

Source: Nuclear Regulatory Commission 2008-2009 Information Digest



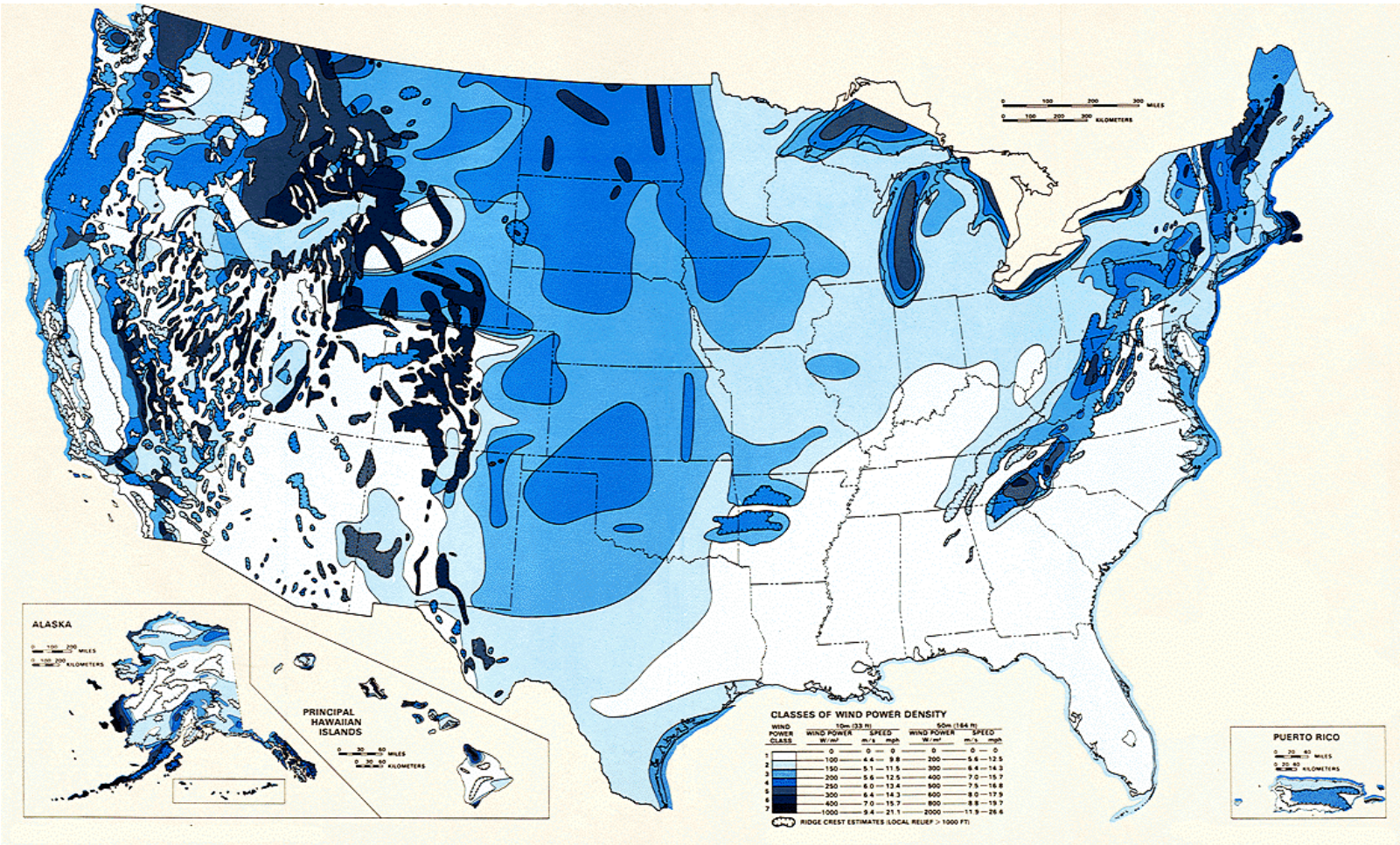
U.S. Geothermal Energy Potential



Source: DOE Energy Efficiency and Renewable Energy Program Website.
<http://www1.eere.energy.gov/geothermal/maps.html>



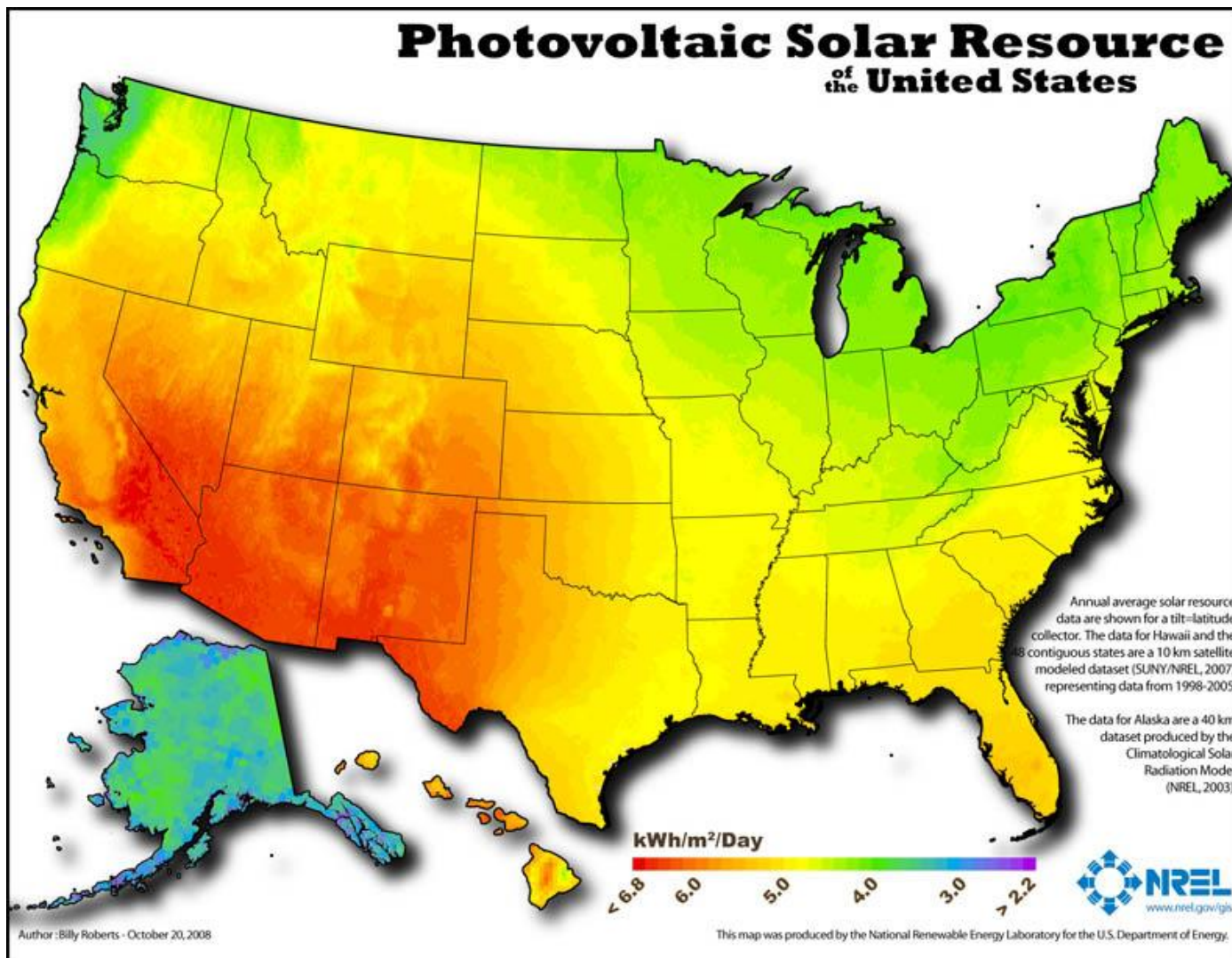
Average Annual Wind Power Potential



Source: National Renewable Energy Laboratory, Wind Energy Resource Atlas of the United States (Oct 1986)

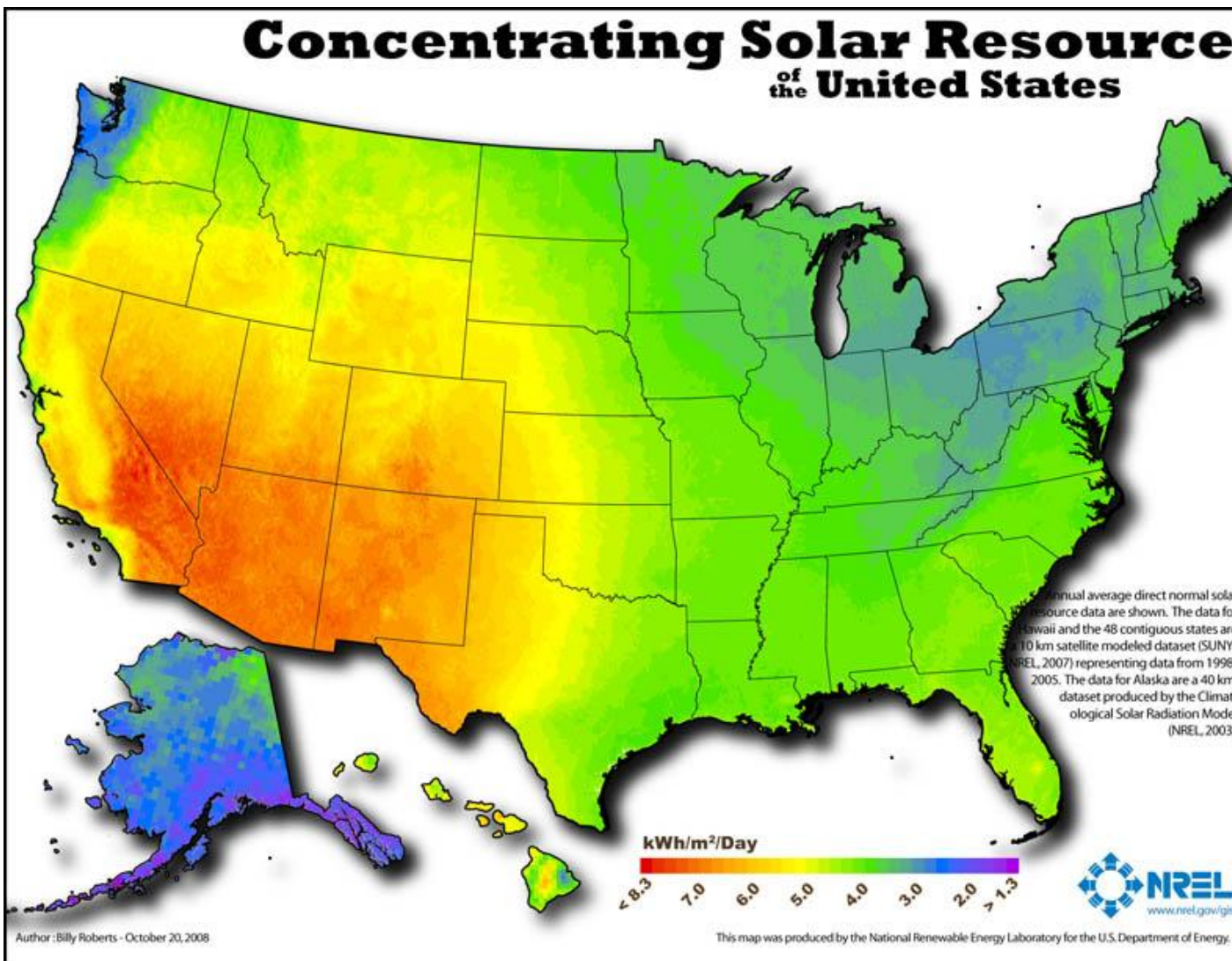


Solar Energy Potential



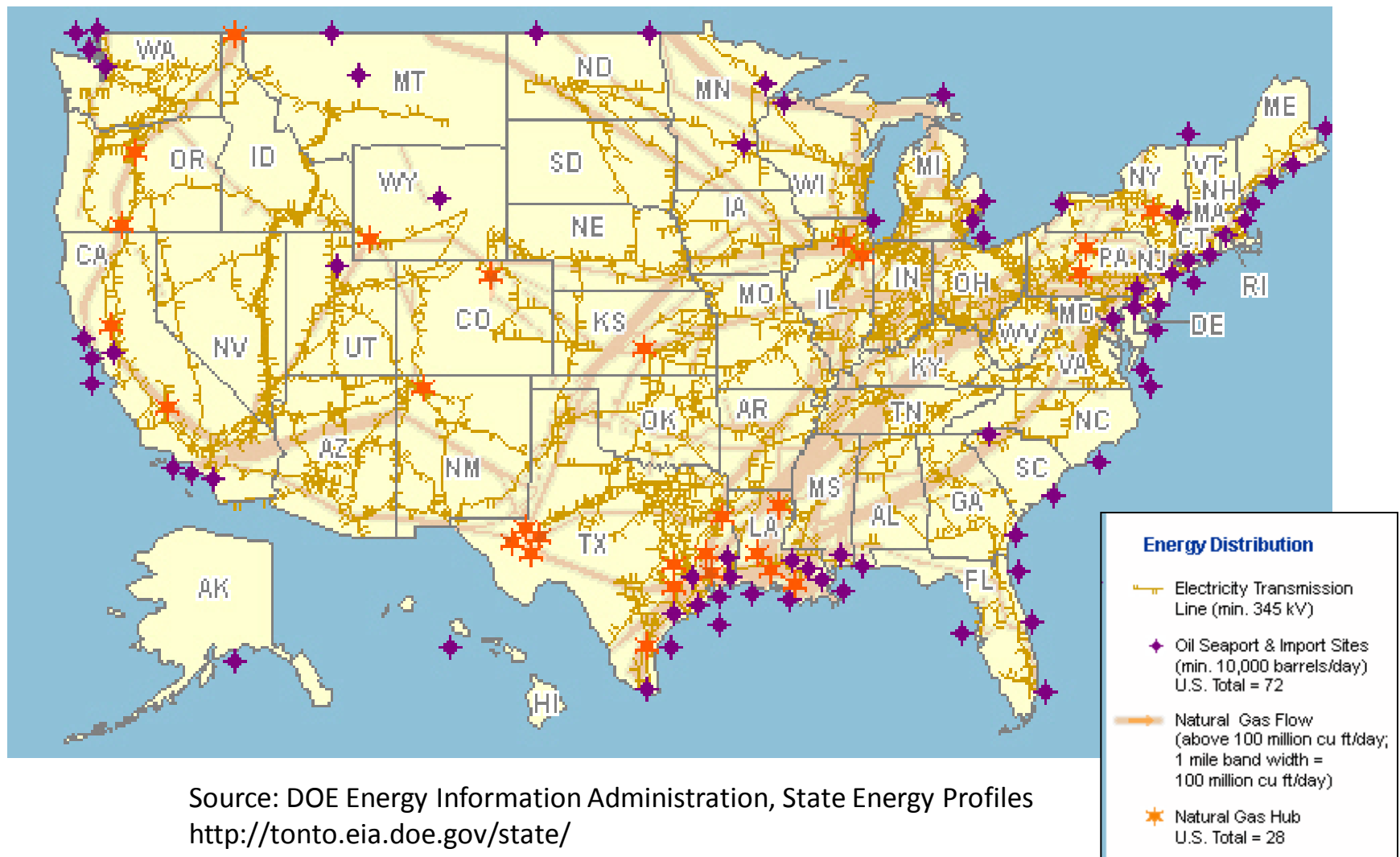


Solar Energy Potential





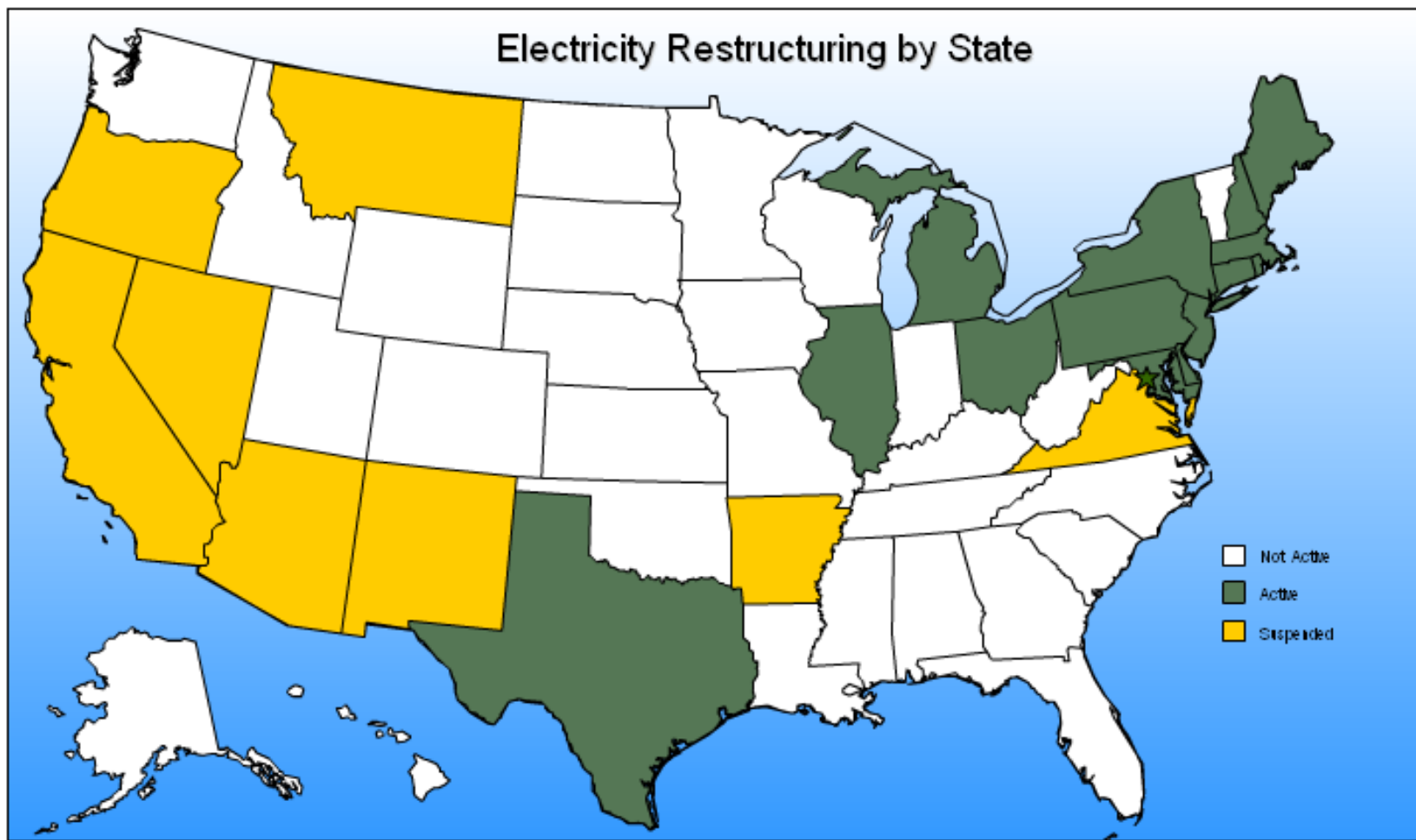
U.S. Energy Distribution Nodes



Source: DOE Energy Information Administration, State Energy Profiles
<http://tonto.eia.doe.gov/state/>



Deregulation



Source: Energy Information Administration



Partnering Opportunities

Federal



NIST
National Institute of
Standards and Technology
U.S. Department of Commerce



State PUCs



Industry

NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

EEI EDISON ELECTRIC
INSTITUTE

EPRI | ELECTRIC POWER
RESEARCH INSTITUTE

GRIDWISE ALLIANCE | **GALVIN**
ELECTRICITY
INITIATIVE

APPA American
Public Power
Association

IEEE
Celebrating 125 Years
of Engineering the Future