# ELECTRICITY 101

# Introduction

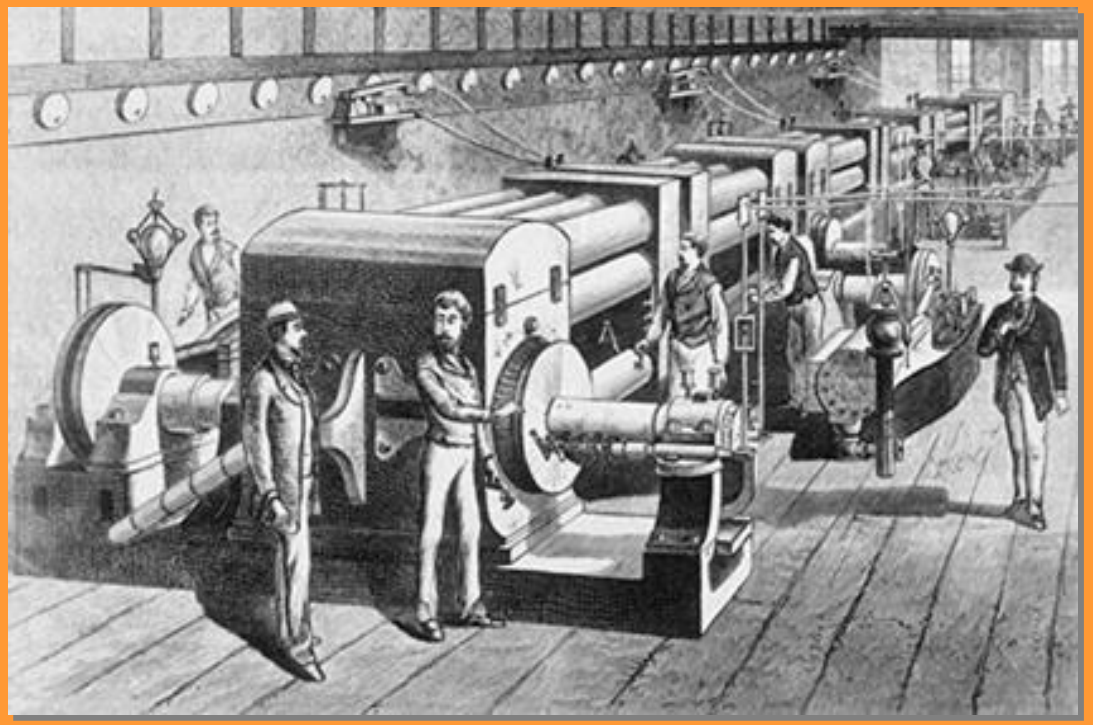
"Is it a fact—or have I dreamt it—that, by means of electricity, the world of matter has become a great nerve, vibrating thousands of miles in a breathless point of time?"

– Nathaniel Hawthorne, 1804-1864
American Novelist

# A BRIEF HISTORY OF THE U.S. POWER INDUSTRY

# The Early Years

- **Mid-1700s—Interest in harnessing power of electricity**
- **1882—First workable electric system built by Edison at Pearl Street Station**



Pearl Street Station, New York

Schenectady Museum:
Hall of Electrical History Foundation

# Industry Formation

- **1890s—Electric utilities began to develop primarily in urban areas because of economies of scale**
- **Industry had characteristics of a "natural monopoly"**
  - *—A natural monopoly is where, for technical and social reasons, it is most efficient to have only one provider of a good or service*
    - ***Provided service regarded as vital to economic and social fabric of community (i.e., a "public utility")***
    - ***Operated through large, integrated networks***
    - ***Highly capital-intensive***
- **1907—State regulation of electric utilities began in New York and Wisconsin**
  - *Regulation spreads to two-thirds of states by 1920*

# Industry Formation

- By 1920s—Most urban areas are electrified
- Exclusive utility franchises (monopoly rights) also came with an “obligation to serve” all customers in the defined regions
- Limited federal regulation of multi-state utilities


Times Square, New York, 1920s

# Holding Companies

- **1920s—Many small utilities were consolidated and became parts of larger "holding companies"**
  - *Holding companies own other holding companies and operating companies. This is a common corporate structure in many industries.*
  - *The rapid growth, consolidation, and complexity of the utility industry outpaced the ability of many local regulators at the time.*

- **1929—Stock market crash revealed that many holding companies were over-leveraged**
  - *As a result, federal and state governments strengthened utility regulation.*

# Federal Regulation

**1935: Congress passed federal legislation addressing interstate utility operations**

- **The Federal Power Act**
  - *Interstate sales of electricity*
  - *Primarily regulates shareholder-owned utilities*
- **The Public Utility Holding Company Act (PUHCA)**
  - *Corporate structure of utilities*

FDR signs legislation

# Federal Regulation

- **Federal and state regulatory scrutiny has grown significantly since 1935**
  - *The federal government regulates interstate power sales and services; mergers; corporate structure*
  - *State governments regulate retail electric service; mergers; facility planning and siting*

- **Other federal and state laws, rules, and regulations also apply to the electric utility industry, including, but not limited to:**
  - *Anti-trust laws / Dept. of Justice / FTC*
  - *SEC requirements, including Sarbanes-Oxley*
  - *Environmental regulations/EPA*

# America Electrifies 1930-1970

- **Electricity finds many new applications in homes and businesses**
- **New power plants are built to meet customer needs**
  - *Because of economies of scale, electricity prices actually go down as larger and more efficient power plants come on line*
- **Transmission lines begin to connect utilities to one another**
  - *What we refer to today as "the grid" begins to take shape*

# 1970s: Rate Regulation Re-examined

- **To encourage competition, Congress re-examined rate regulation model of natural monopolies, including:**
  - *Railroad, natural gas, trucking, airline, and telecom industries*
  - **Public Utility Regulatory Policies Act of 1978 (PURPA)**
    - *Requires utilities to purchase electricity produced by cogenerators and small power producers*
    - *Federal government expands regulatory role in state rate policies*

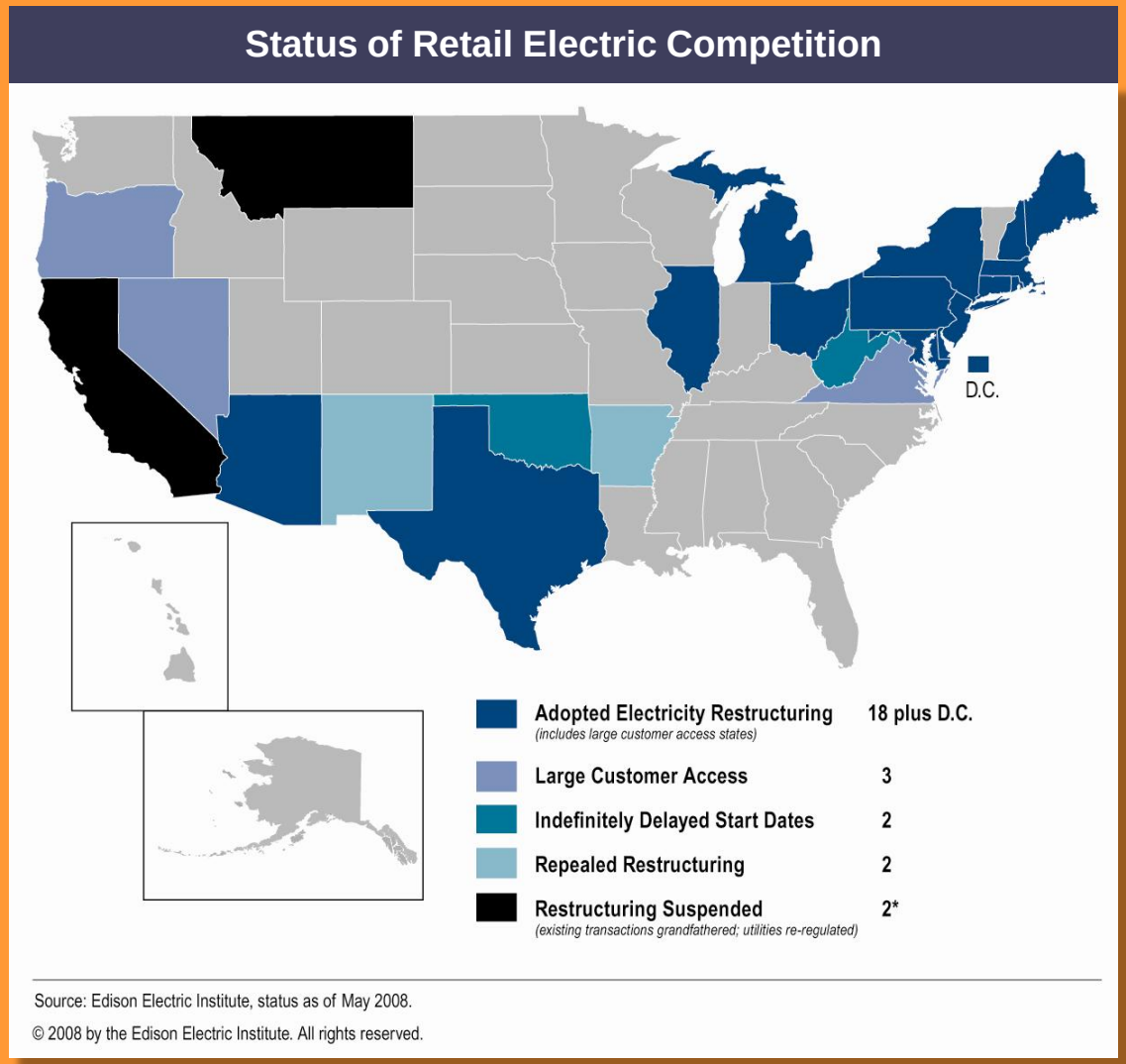

1979—Motorists line up for first day of gas rationing

# Energy Policy Act of 1992

- Creates new class of "exempt wholesale generators" to sell power in competitive wholesale markets
- Expands FERC's authority to order transmission-owning utilities to provide transmission access to other wholesale market players
- Increases energy-efficiency standards for buildings, appliances, and federal government
- Encourages development of alternative fuels and renewable energy
- Expands clean coal programs
- Reforms and streamlines nuclear plant licensing

# 1990s: Some States Move to Retail Choice

- During the 1990s, a number of states adopted different models to encourage competition among generators to serve retail customers



# Energy Policy Act of 2005

## Electricity Initiatives:

- Requires mandatory reliability standards
- Promotes transmission investment and facilitates transmission siting
- Repeals PUHCA and reforms PURPA
- Promotes fuel diversity
- Increases energy efficiency
- Gives FERC stronger consumer protection, anti-market manipulation authority

# Energy Independence and Security Act of 2007

## Electricity Initiatives:

- Establishes stricter efficiency standards for variety of appliances; includes initiatives to strengthen building codes for commercial buildings
- Includes incentives to encourage development and production of electric drive transportation technologies, including plug-in hybrid electric vehicles
- Expands federal RD&D program for carbon capture and storage technologies
- Encourages deployment of smart grid technologies with federal matching funds for investment costs
- Directs FERC to create action plan on demand response

# HOW DOES THE SYSTEM WORK?

# Electricity: It's All About Conversions

- Energy can neither be created nor destroyed - it can only be transformed (converted) from one form to another
- Our lives are surrounded by energy conversion technologies:
  - Chemical to thermal
    - Home furnace using fuel oil, natural gas, or wood
  - Chemical to thermal to mechanical
    - Automobile engine
  - Chemical to electrical
    - Fuel cell
  - Electrical to mechanical
    - Electric motor
  - Electrical to radiant
    - Toaster, light bulb
- Power plants are simply energy-conversion facilities converting fuel and energy sources into electricity

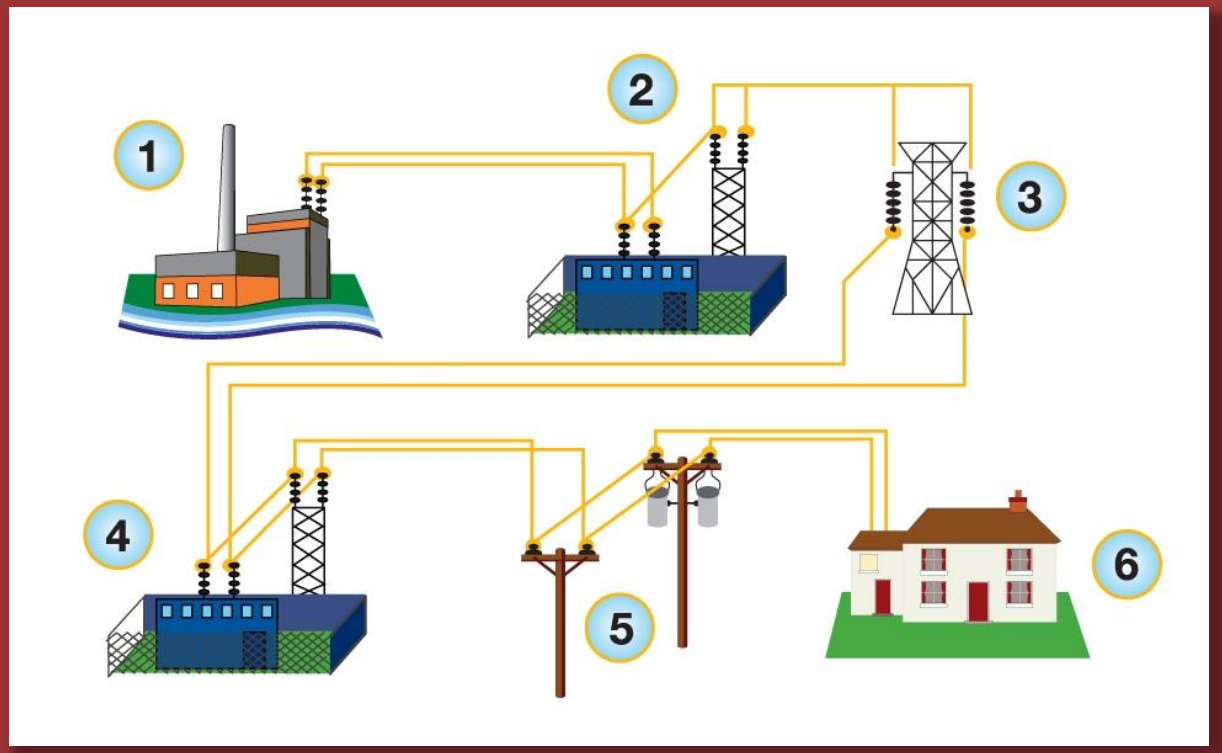
# Mega What?

- **Watt (W)**—The basic unit of measure of electric power. The power dissipated by a current of 1 ampere flowing across a resistance of 1 ohm.
- **Kilowatt (kW)**—A unit of power equal to 1,000 watts.
- **Kilowatt Hour (kWh)**—A unit by which residential and most business customers are billed for monthly electric use. It represents the use of one kilowatt of electricity for one hour.
  - *A 100-watt light bulb burning for 10 hours would use 1 kilowatt-hour of electricity.*
- **Megawatt (MW)**—A unit of power equal to one million watts.
- **Megawatt Hour (MWh)**—The use of 1 million watts (or 1,000 kilowatts) of electricity for one hour. This term is used most often for large-scale industrial facilities and large population centers.
  - *The average U.S. household uses 11.2 MWh (11,202 kWh) of electricity every year.*
- **Power** (measured in Watts) equals its current (measured in Amps) times its voltage (measured in Volts) or Volts X Amps = Watts.

# How Does the System Work?

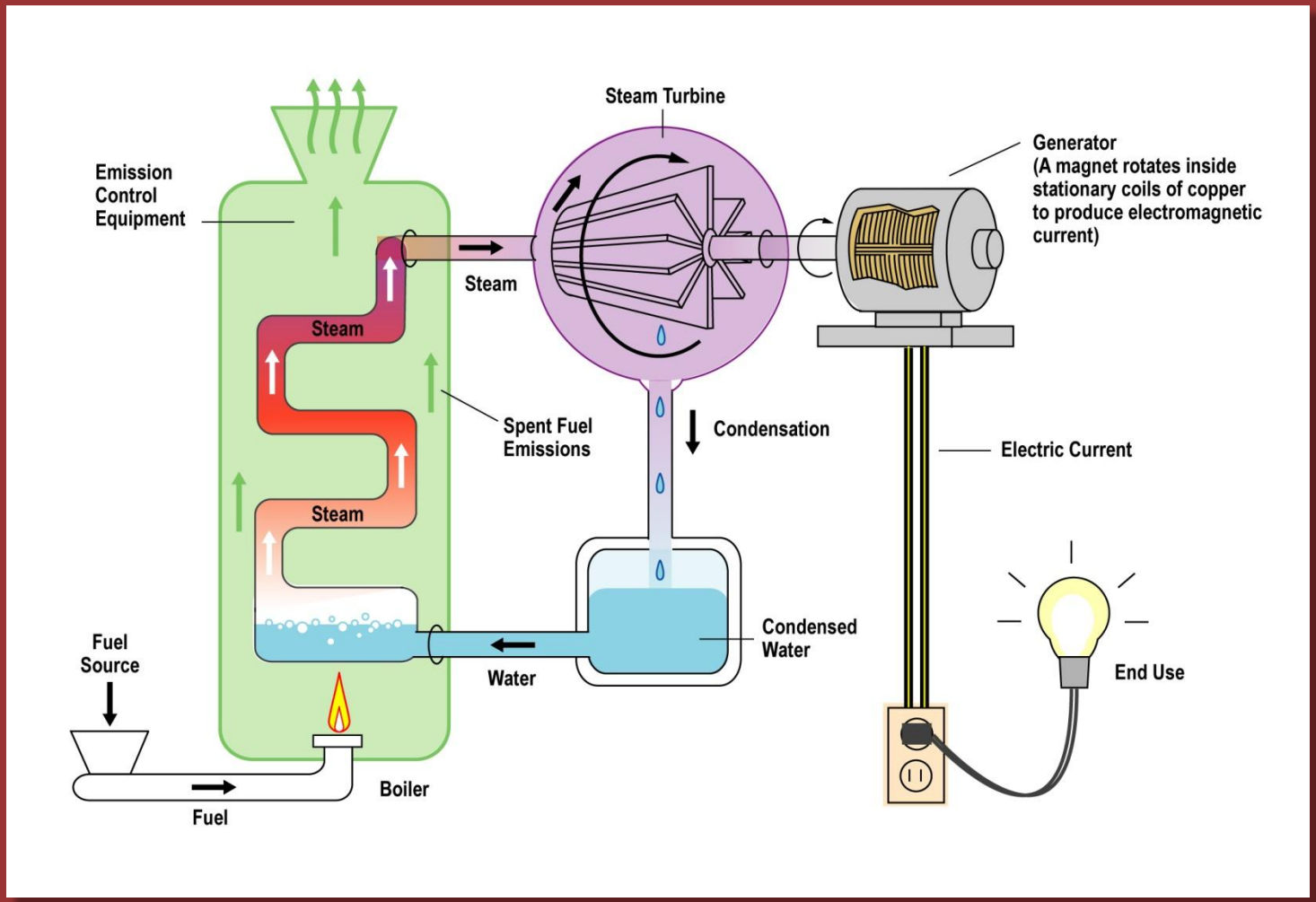
Electricity, Where It Comes From
And How It Gets to Me

1. Electricity is generated and leaves the power plant
2. Its voltage is increased at a “step-up” substation
3. The energy travels along a transmission line to the area where the power is needed
4. Once there, the voltage is decreased or “stepped-down,” at another substation
5. A distribution power line carries the electricity
6. Electricity reaches your home or business



# Generation

## Generating Power and Getting It to the Consumer



# Transmission

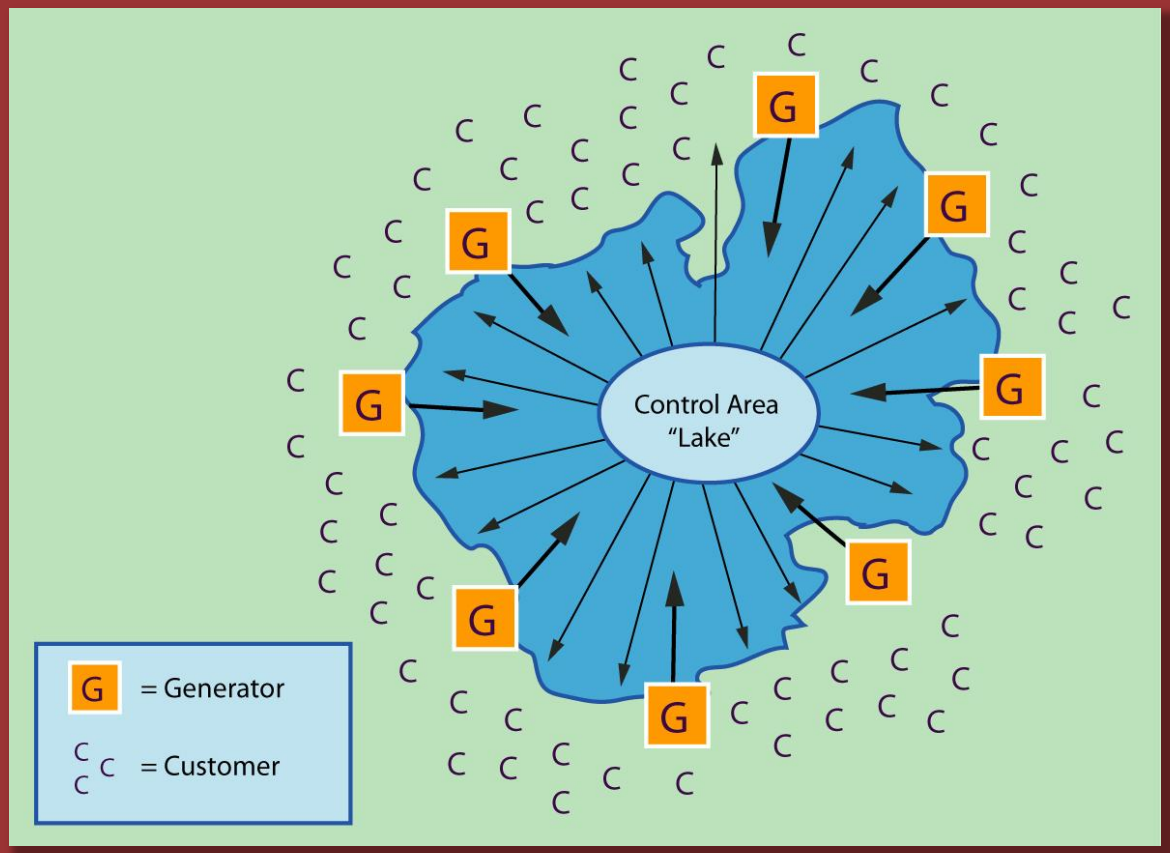
- Thick wires on tall towers carry high-voltage electricity from power plants to local communities and connect one region to another

# Distribution

- Thinner wires on smaller towers (or in some cases underground) carry much lower voltage power to homes and businesses

# Sounds Simple, What's the Catch?

- **Electricity cannot be stored, so supply (generation) must be produced exactly when needed to meet customer demand and to avoid system failure**

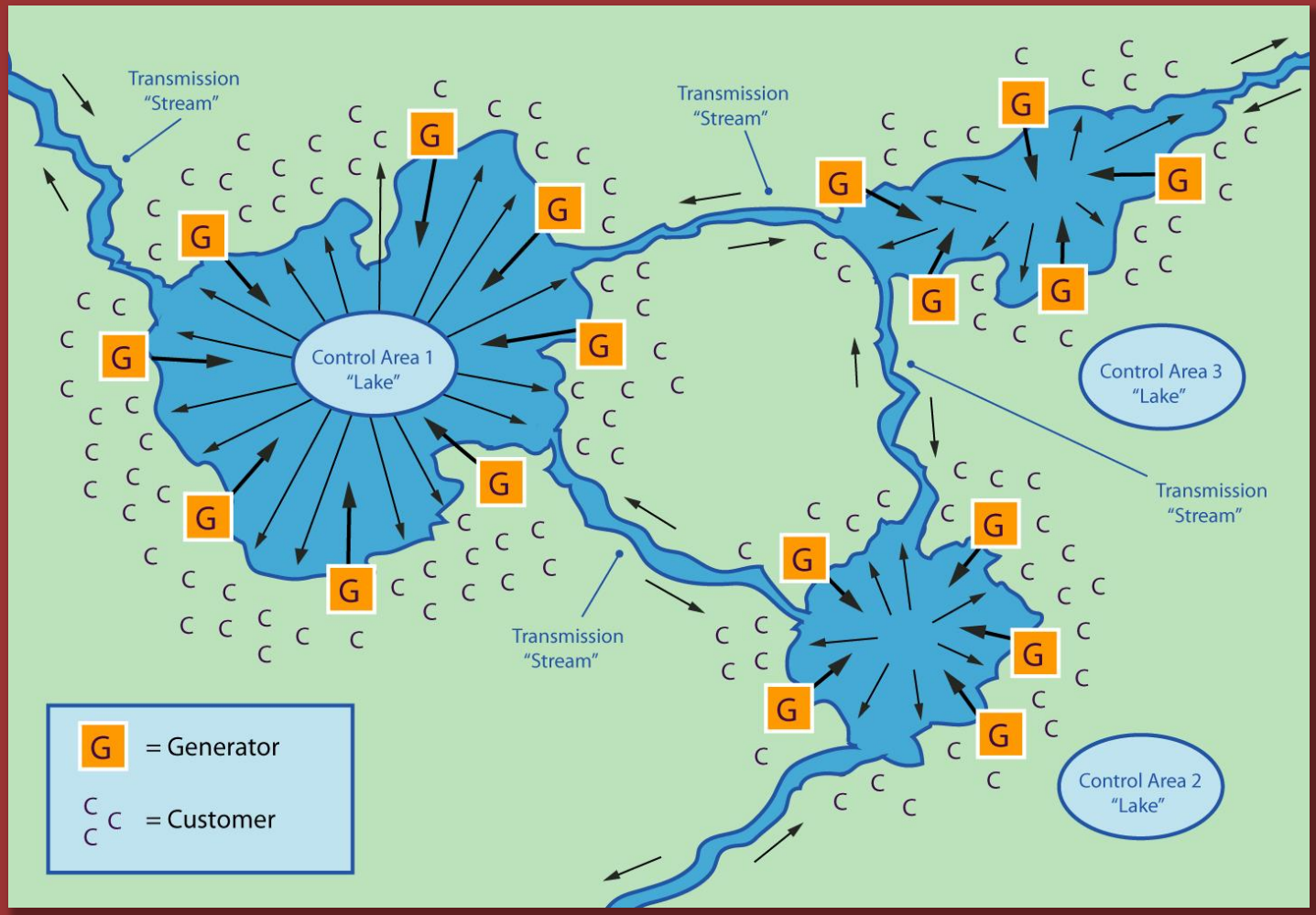



- **Level in "lake" must be kept constant at all times**
- **Laws of physics dictate that power flows on path of least resistance, not necessarily where we'd like it to**

Individual "Lake" Model

# Sounds Simple, What's the Catch?

## "Lakes" Network Model

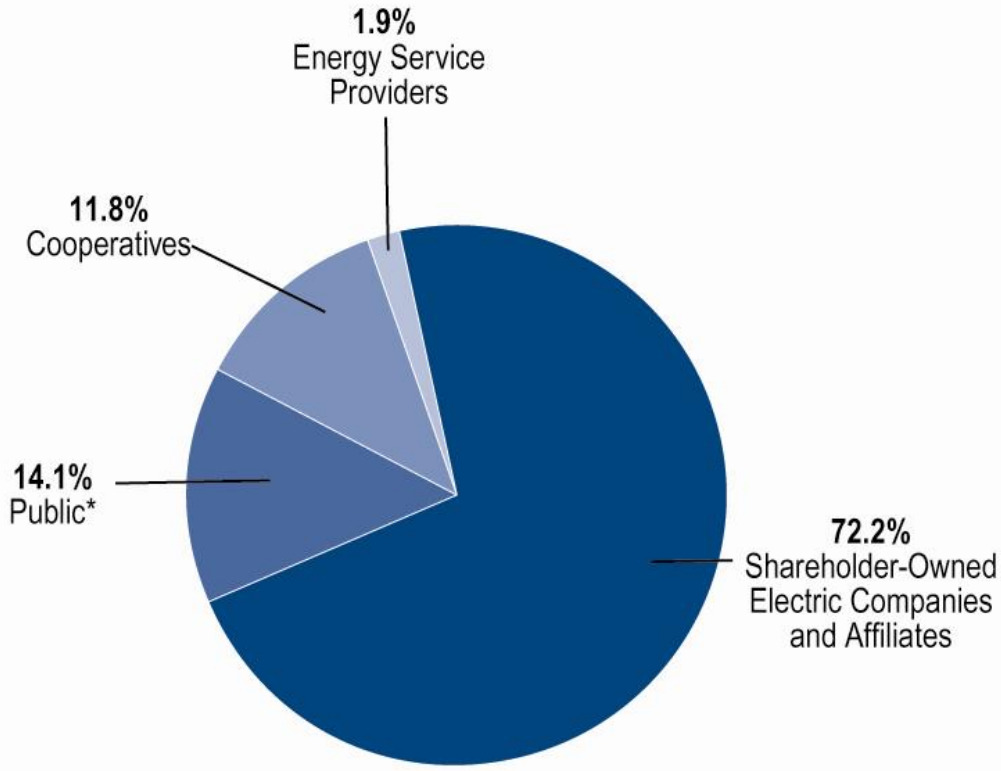


# INDUSTRY OVERVIEW

# Different Types of Ownership-Structure

- **Shareholder-Owned Utilities**
- **Cooperatively Owned Utilities**
- **Government-Owned Utilities**
  - *Federally Owned Utilities*
  - *State-Owned*
  - *Municipally Owned*
  - *Political Subdivisions*

# Percentage of Customers Served By Each Type of Provider

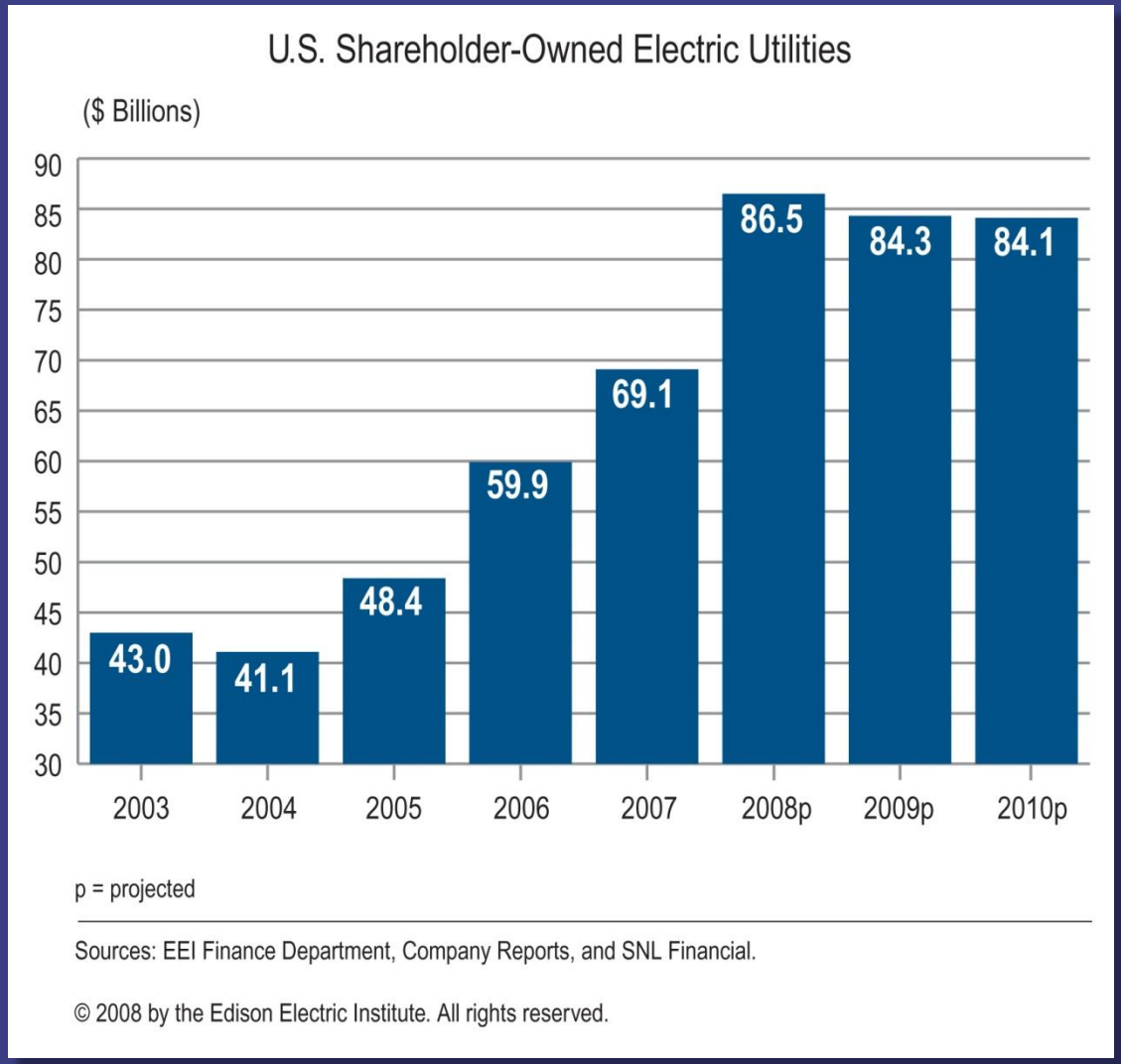



* Includes state projects, political subdivisions, and municipal systems.
Note: Federal Utilities serve <0.1% of customers.

Source: U.S. Department of Energy, Energy Information Administration (EIA), *Monthly Electric Utility Sales and Revenues Report with State Distributions (EIA-826).*

# Capital Expenditures of the Shareholder-Owned Electric Industry

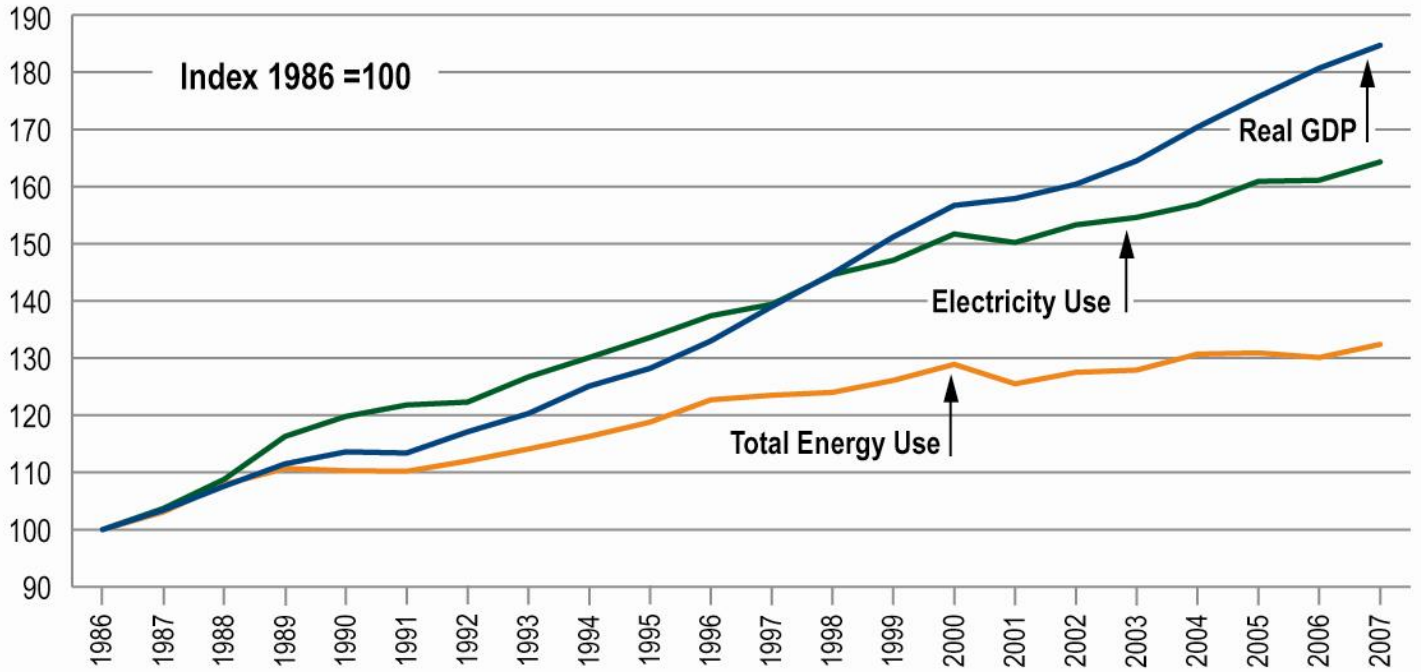
- **Industry continues to increase capital spending to keep pace with growing demand for electricity.**



# THE INDUSTRY'S RECORD

# Electricity & GDP

## U.S. Economic Growth Is Linked to Electricity Growth

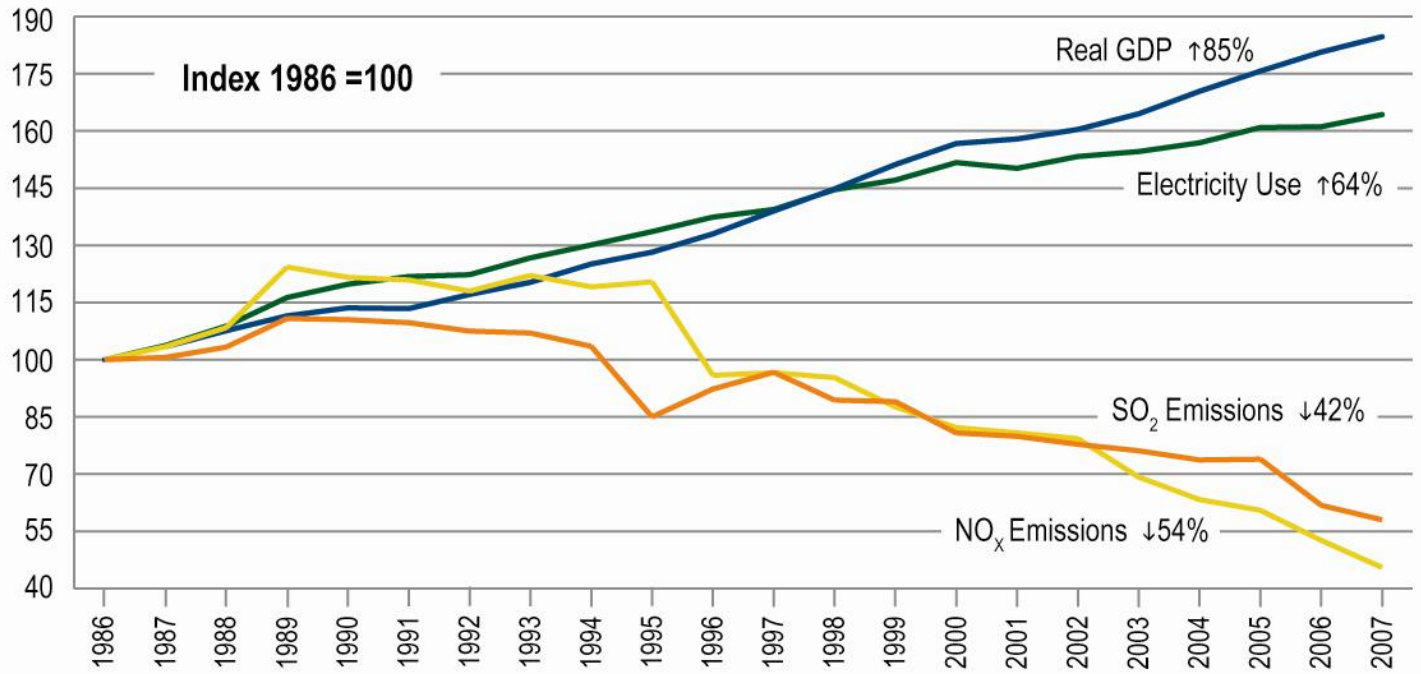



1986 represents the base year. Graph depicts increases or decreases from the base year.

Source: U.S. Department of Energy, Energy Information Administration (EIA).

# Increasingly Clean

## Power Plants Reduce Emissions Despite Increasing Electricity Demand



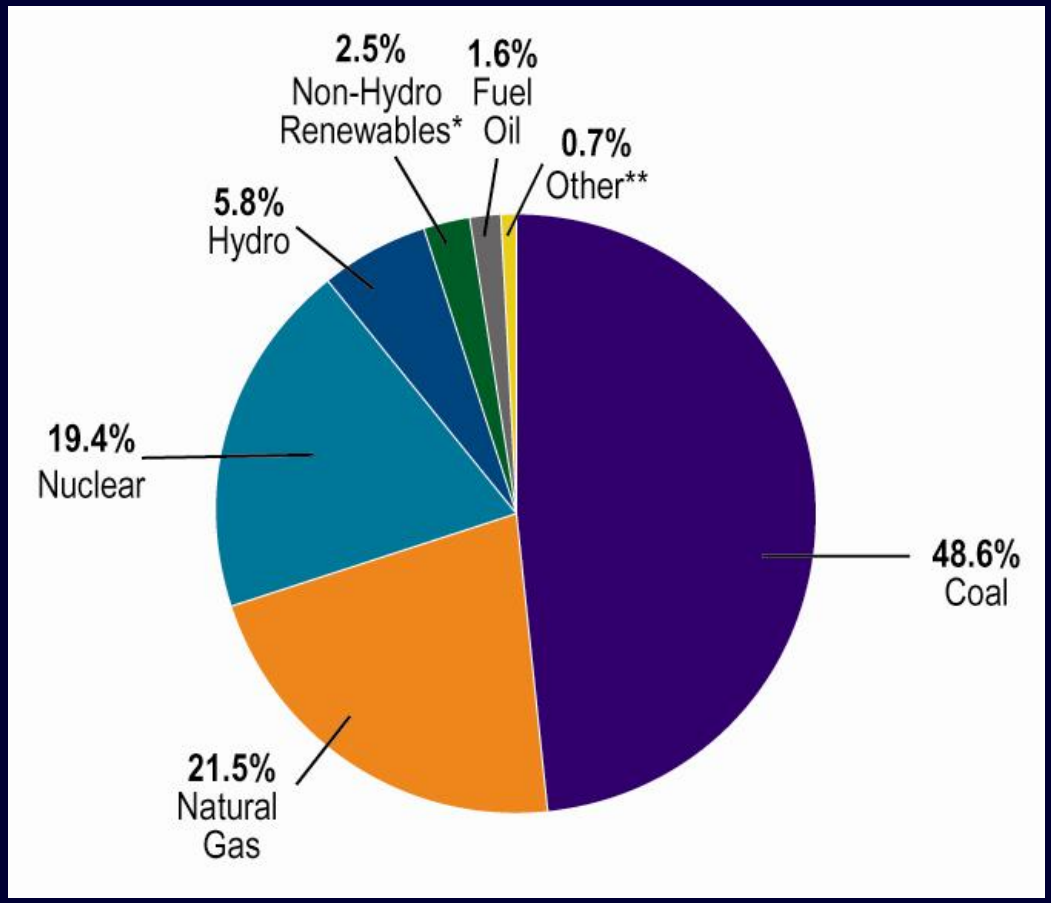

1986 represents the base year. Graph depicts increases or decreases from the base year.

Sources: U.S. Department of Energy, Energy Information Administration (EIA), U.S. Environmental Protection Agency (EPA), and U.S. Bureau of Economic Analysis.

# FUEL SOURCES

# What Are the Fuels Used to Generate Electricity?

## 2007 National Fuel Mix



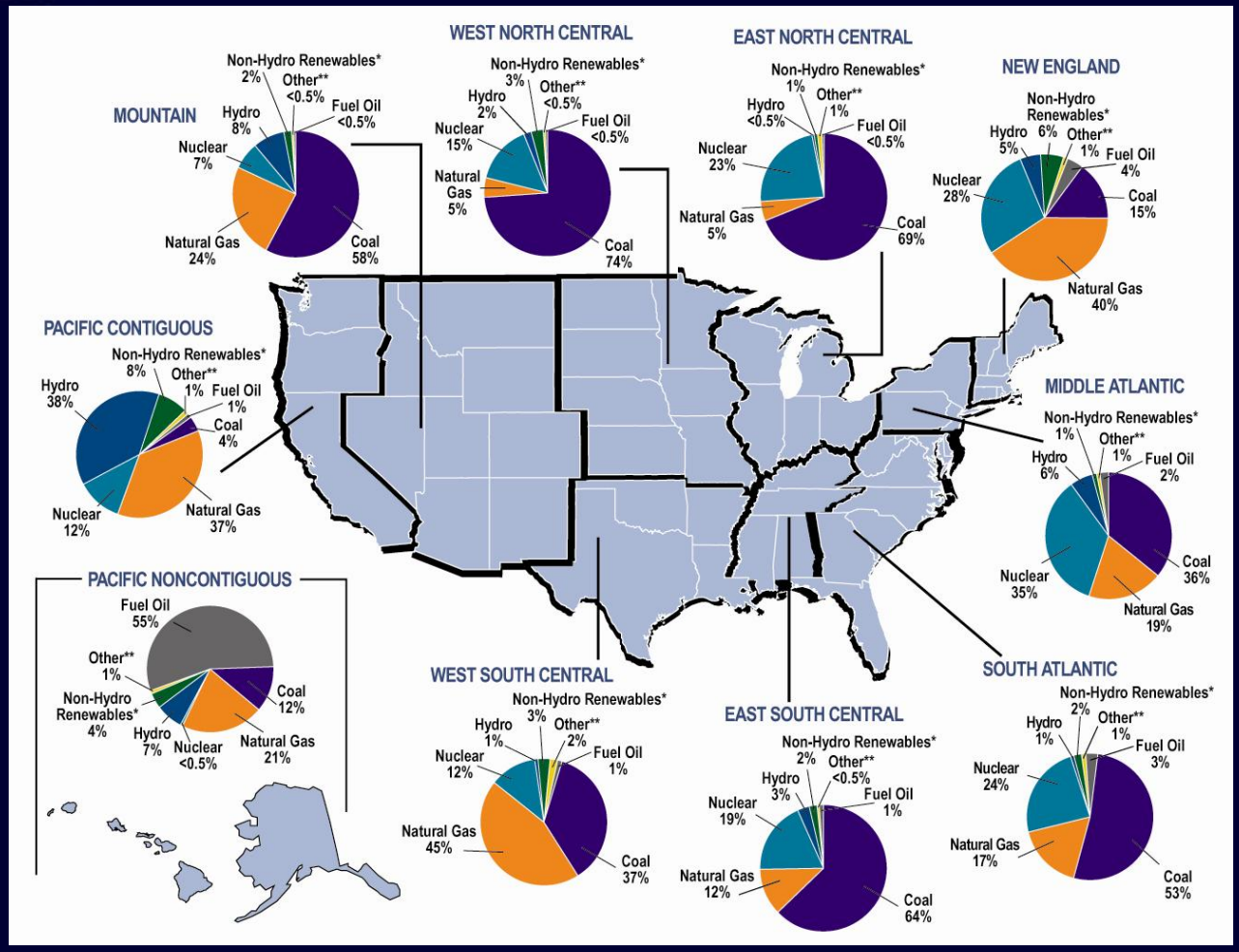

*Includes generation by agricultural waste, landfill gas recovery, municipal solid waste, wood, geothermal, non-wood waste, wind, and solar.

** Includes generation by tires, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

Sum of components may not add to 100% due to independent rounding.

Sources: U.S. Department of Energy, Energy Information Administration, Power Plant Report (EIA-906), and Combined Heat and Power Plant Report (EIA-920).

# Different Regions of the Country Use Different Fuel Mixes to Generate Electricity

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Sources: U.S. Department of Energy, Energy Information Administration, Power Plant Report (EIA-906), and Combined Heat and Power Plant Report (EIA-920).

# Fuel Diversity: Key to Affordable and Reliable Electricity

- No individual fuel is capable of meeting all of our nation's electricity demands
- Maintaining the diversity of available fuel resources helps to ensure that we do not become too dependent on one fuel source
- Fuel diversity protects consumers from contingencies such as fuel unavailability, price fluctuations, and changes in regulatory practices
- Fuel prices greatly affect the price of electricity—today, fuel costs are on the rise

# Environmental Aspects of Fuel Diversity

- Fuel choices allow environmental impacts to be balanced and still assure reliable, cost-effective power supply to consumers
- Any fuel source for generating electricity involves some environmental impact
- Environmental effects can be air emissions, water quality impacts, fish and wildlife impacts, waste disposal concerns, and aesthetics
- Environmental impacts are significantly less than they were a decade ago

# Electricity Generation from Coal

- Coal is a fuel source for almost 49% of electricity generated in the United States
- Most abundant domestic energy resource—U.S. has about 25% of world's total coal reserves (275 billion tons) and consumes 25% of world's coal used annually
- Significant improvements in pre- and post-combustion emission reduction technology
- Like prices for other fossil fuels, coal prices are increasing, rising from $1.25/million Btu in 1999 to $1.78/million Btu in 2007
- Developing clean coal technologies, including carbon capture and storage technologies; resolving coal delivery problems; and maintaining coal's ability to compete on costs are key drivers to future use of coal

# Electricity Generation from Natural Gas

- 21.5% of total current generation is natural gas-based; in past decade, almost 95% of new plants have been natural gas-based
- Lower emissions than other fossil fuels
- Low capital costs and regulatory barriers for other fuels make natural gas-based generation easier to site and build
- Declining production, limited access to natural gas supplies, and rising demand are causing natural gas prices to increase dramatically
- The average price electric utilities paid for natural gas rose from $2.38/million Btu in 1998 to $7.50/million Btu in 2007
- Large volumes of onshore and offshore natural gas are off limits due to moratoria, regulation
- U.S. isolated from global market and its plentiful supply and lower prices

# Electricity Generation from Nuclear

- 104 nuclear power plants in the U.S. provide 19.4% of this nation's electricity
- Nuclear power produces no sulfur dioxide, nitrogen oxides, mercury, or carbon dioxide emissions
- Uranium is plentiful and efficient. One pellet of enriched uranium—the size of the tip of your little finger—is the equivalent of 17,000 cubic feet of natural gas, 1,780 pounds of coal, or 149 gallons of oil
- Existing nuclear power plant performance continues to improve
- High construction costs and used fuel disposal are two major challenges to building new plants

# Electricity Generation from Hydropower

- 5.8% of electricity generation is from hydro—largest source of renewable energy
- Low-cost domestic fuel, emissions free, abundant in some regions, helps contribute to system reliability
- Provides flood control, navigation, irrigation, recreational opportunities, and fish and wildlife benefits
- Difficult licensing renewal process often results in generating capacity reductions and loss of flexibility to operate facility for electric reliability purposes. Energy Policy Act of 2005 contains provisions to improve the hydropower licensing process

# Electricity Generation from Non-Hydro Renewables

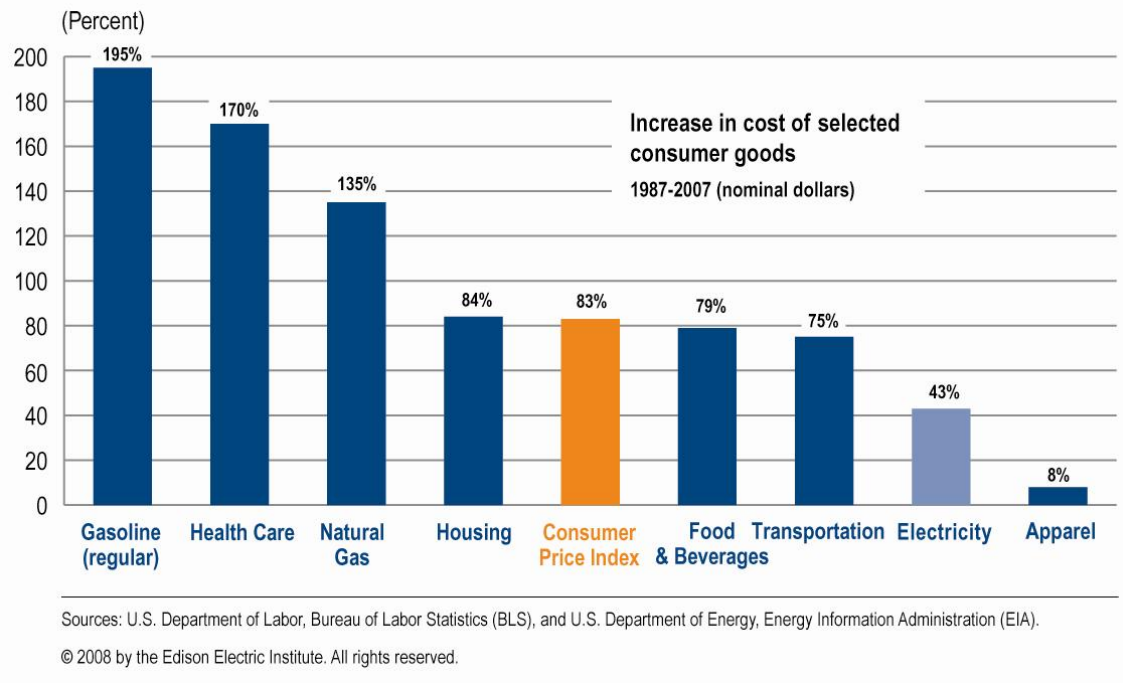
- Generation from non-hydro renewables and other sources is 3.2%
- Biomass produces 1.3% of generation; wind, 0.8%; geothermal, 0.4%
- Largely $CO_2$ emission free. (Emissions from biomass combustion are $CO_2$-neutral to the extent that they represent atmospheric carbon fixed in plant material through photosynthesis, a process that can be repeated indefinitely.)
- Renewable technologies face high initial capital costs
- Current and future challenges include geographic limitations, intermittent nature, transmission availability, frequent expiration of production tax credit, environmental and aesthetic challenges

# Today's Electric Utility Rate Environment

# Electricity: A Great Value

- The national average price for electricity today is less than what it was in 1987, when adjusted for inflation
- Even with recent price increases, the growth rate for electricity prices remains comparable to, and even lower than, other important consumer goods

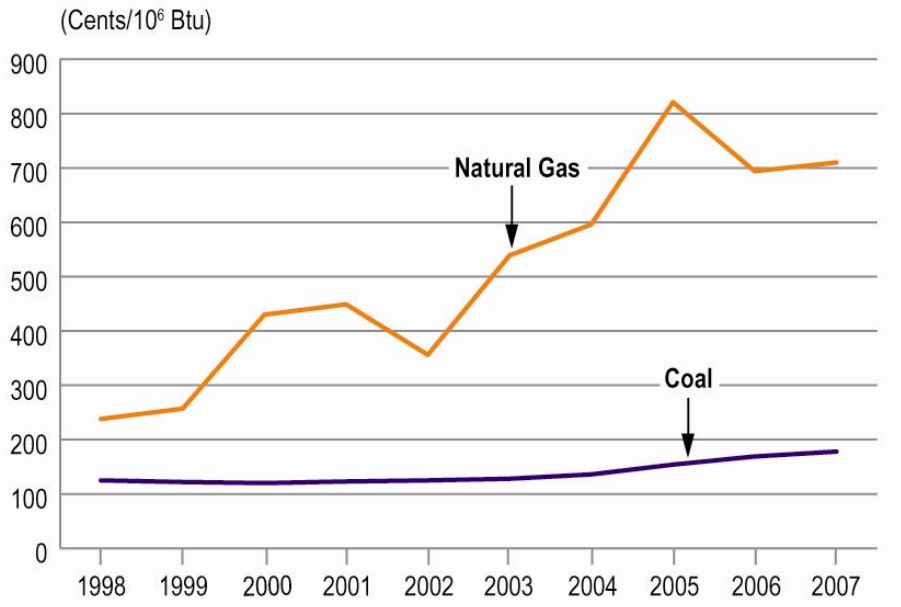
**Changes in Electricity Prices Compared To Other Consumer Products**



# The Costs to Generate Electricity Are Rising

- Fuel prices greatly affect the price of electricity
- Fuel prices have risen considerably since 1999, particularly for natural gas
- At the same time, demand for electricity continues to grow

## Average Cost of Fossil Fuels




The years 2002 and beyond include data for electric utilities, independent power producers, and commercial and industrial combined heat and power producers. The years prior to 2002 include data for electric utilities only.

U.S. Electric Utility: Owns and/or operates facilities within the United States for the generation, transmission, distribution, or sale of electric energy primarily for use by the public. This includes shareholder-owned utilities, public power, and cooperatives.

Source: U.S. Department of Energy, Energy Information Administration (EIA), Electric Power Monthly, Table 4.1.

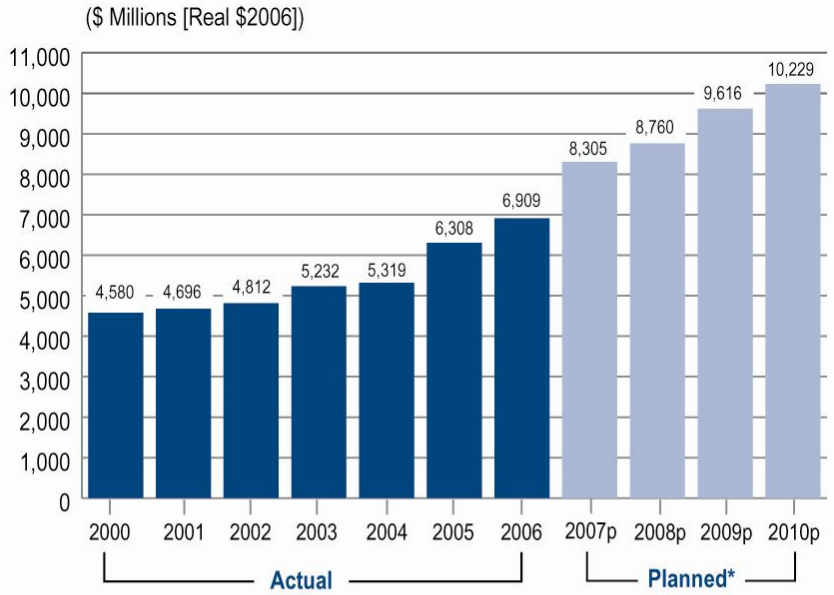
# Demand for Electricity Is Growing

- **While efficiency improvements have had a major impact in meeting national electricity needs relative to new supply, the demand for electricity continues to increase**
  - *According to EIA, electricity consumption is expected to increase at least 30 percent by 2030*
- **To meet this increasing demand, electric utilities must invest in a new generation of baseload power plants, those that run continuously to meet the country's minimum demand**
  - *According to EIA, 240 gigawatts (GW) of new capacity will be needed by 2030*

# Infrastructure Investment Costs Are Growing

- **Significant increase in investment coinciding with surge in generating capacity**
  - *Since 2000, the electric power industry has invested more than $46 billion in nation's transmission system*
  - *Preliminary data indicate shareholder-owned electric companies are planning to invest $37 billion from 2007-2010*
- **Benefits include newer technologies, bigger markets, lower prices, reliability**

**Actual and Planned Transmission Investment By Shareholder-Owned Electric Utilities**

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Note: The Handy-Whitman Index of Public Utility Construction Costs used to adjust actual investment for inflation from year to year. The GDP Deflator used to adjust planned investment for inflation from year to year. Data represent both shareholder-owned utilities and stand-alone transmission companies.

*Planned total industry expenditures are estimated from 85% response rate to EEI's Electric Transmission Capital Budget & Forecast Survey. Actual expenditures from EEI's Annual Property & Plant Capital Investment Survey & FERC Form 1s.

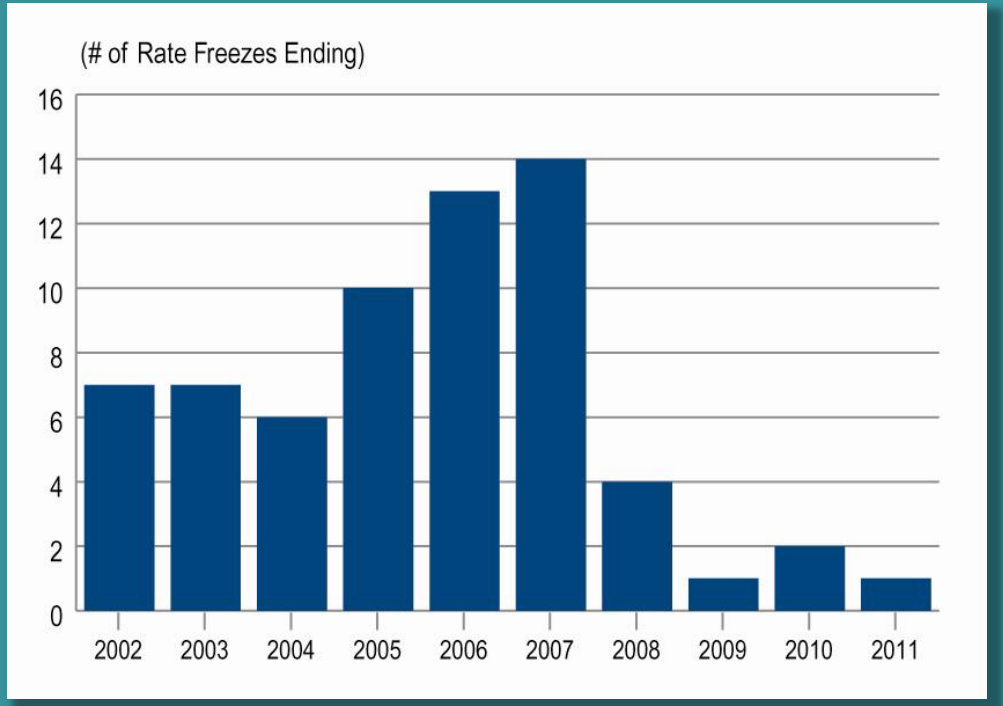
Source: Edison Electric Institute, Business Information Group.

# Environmental Compliance Costs Are Significant

- **All electric utilities are subject to hundreds of environmental rules, including dozens of federal and state air and water quality requirements created in the wake of the Clean Air Act and Clean Water Act**
- **According to the U.S. Environmental Protection Agency, complying with two federal regulations—the Clean Air Interstate Rule and the Clean Air Mercury Rule—would have cost the electric utility industry almost $50 billion between the years 2007 to 2025**
  - These rulemakings were recently overturned. As a result, actual costs will almost certainly be higher since replacement regulatory programs at the federal and state levels will likely be at least as stringent and likely less flexible.
- **The research, design, development, and deployment of new technologies needed to reduce greenhouse gas emissions will require additional investments.**

# Price Caps Set During Industry Restructuring Are Expiring

- As part of the transition to competition, many state policymakers decreed that customers' bills would be frozen, and in many cases reduced, typically for a period ranging from two to ten years
- The first rate caps were put in place in 1997, and the last are set to expire in 2011
- As rate freezes and reductions are being phased out, many customers perceive that their rates are being "increased," when in fact they are reflecting the costs already incurred by utilities



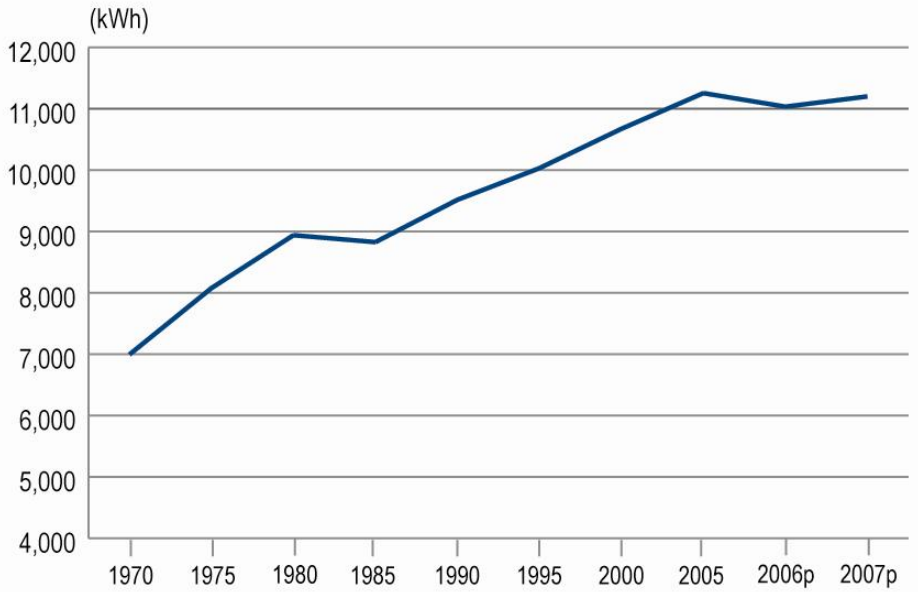
# What Are Utilities Doing To Help Control Rising Prices?

- **Many utilities try to "hedge" or enter into long-term, fixed contracts for fuel at set prices**
  - *Not all companies have this option, and such forward contracts cannot cover all fuel needs*
- **Utilities have increased the productivity (capacity factors) of their power plants while at the same time decreasing their operations and maintenance costs**
- **Electric utilities have taken a leading role in developing energy efficiency and demand response programs for residential, commercial, and industrial customers**
  - *Between 1989 and 2006, electric utility efficiency programs saved about 860 billion kilowatt-hours of electricity—enough electricity to power nearly 76 million average U.S. homes for one year*

# LOOKING FORWARD

# Electricity Use in the Typical U.S. Home

## Annual Electricity Use in the Typical U.S. Home Has Increased 60% Since 1970

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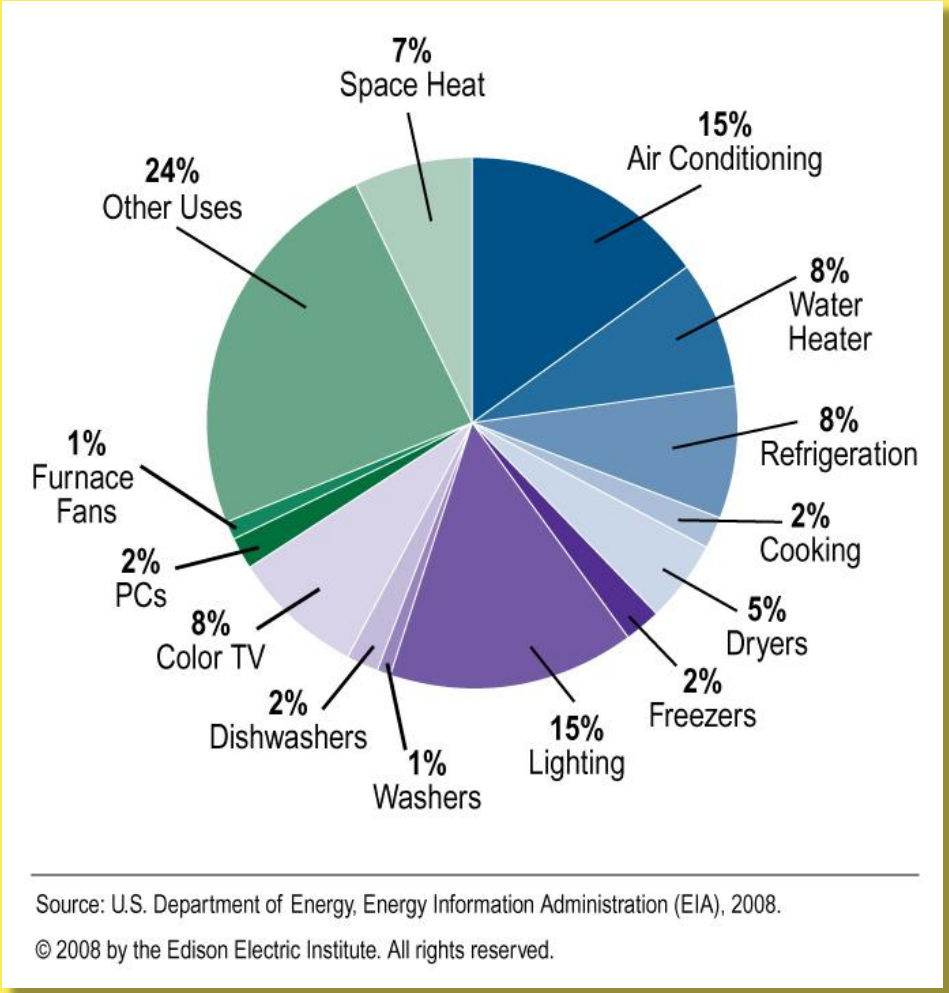
Source: U.S. Department of Energy, Energy Information Administration: Annual Electric Utility Report (EIA-861), and Monthly Electric Utility Sales and Revenues Report with State Distributions (EIA-826).

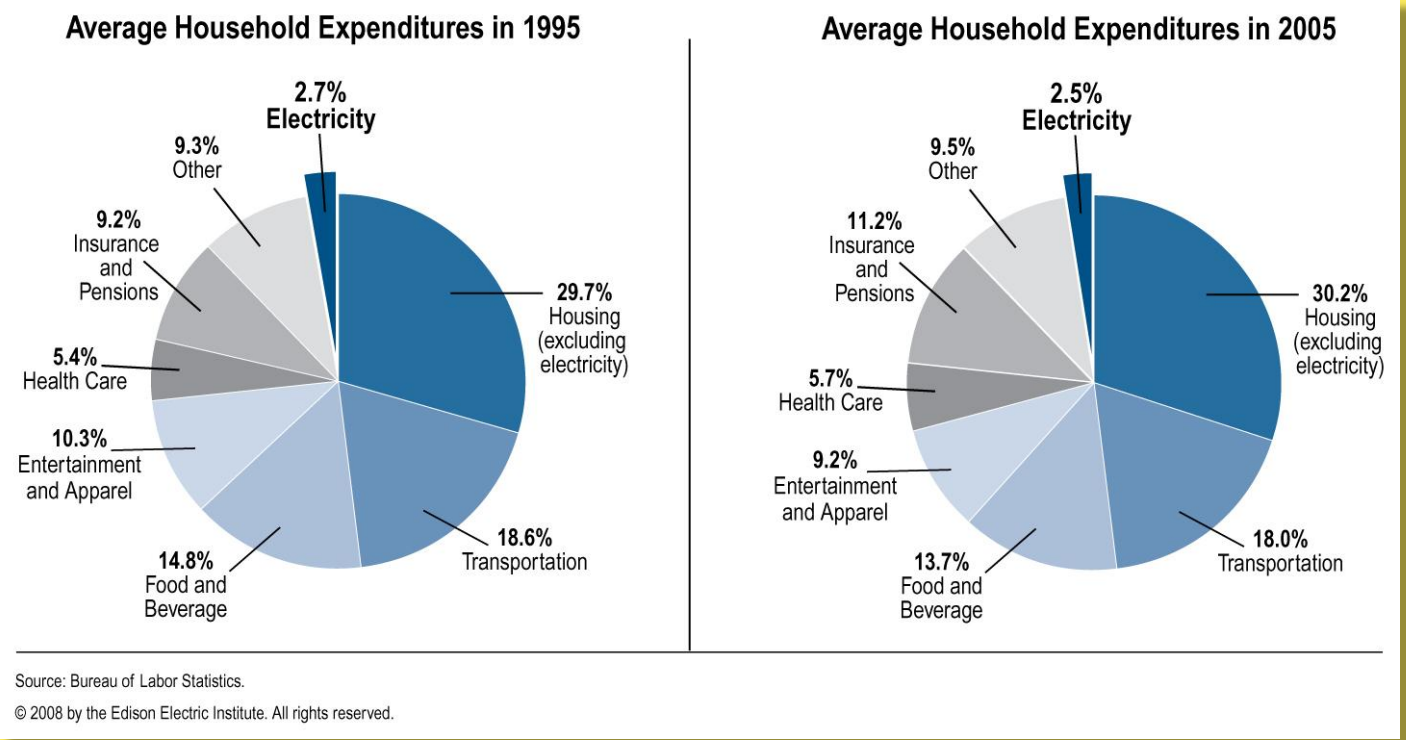
# Residential Electricity Use by End Use

- **A typical U.S. household uses 934 kilowatt-hours of electricity a month.**



# Average Household Expenditures

- **Greater demand for electric power does not translate directly into higher household expenditures**
- **The average American household's total spending on electricity has fallen steadily over time**



# Key Challenges

- Natural gas supply
- Fuel diversity
- Environmental policy
- Coal transportation
- Rising costs of doing business
- Need for increasing infrastructure investment

# Investing in America's Electric Future

- **Electric utilities are entering a new cycle of growth and investment, and a new era of ratemaking**
- **If utilities are able to make investments in infrastructure improvements, benefits will include:**
  - *Long-term reductions in operating costs*
  - *Enhancements of reliability and power quality*
  - *Improvements in competitive power markets*
  - *Cleaner generation*
  - *Increased customer choice and control over energy use*

EDISON ELECTRIC INSTITUTE

**Edison Electric Institute (EEI)** is the association of U.S. shareholder-owned electric companies. Our members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, and represent approximately 70 percent of the U.S. electric power industry. We also have more than 65 International electric companies as Affiliate members, and more than 170 industry suppliers and related organizations as Associate members.

Organized in 1933, EEI works closely with all of its members, representing their interests and advocating equitable policies in legislative and regulatory arenas. In its leadership role, EEI provides advocacy, authoritative analysis, and critical industry data to its members, Congress, government agencies, the financial community and other opinion-leader audiences. EEI provides forums for member company representatives to discuss issues and strategies to advance the industry and to ensure a competitive position in a changing marketplace.

For more information on EEI programs and activities, products and services, or membership, visit our Web site at www.eei.org.