Earth Gauge
A National Environmental Education Foundation Program

Climate, Weather and Energy Consumption

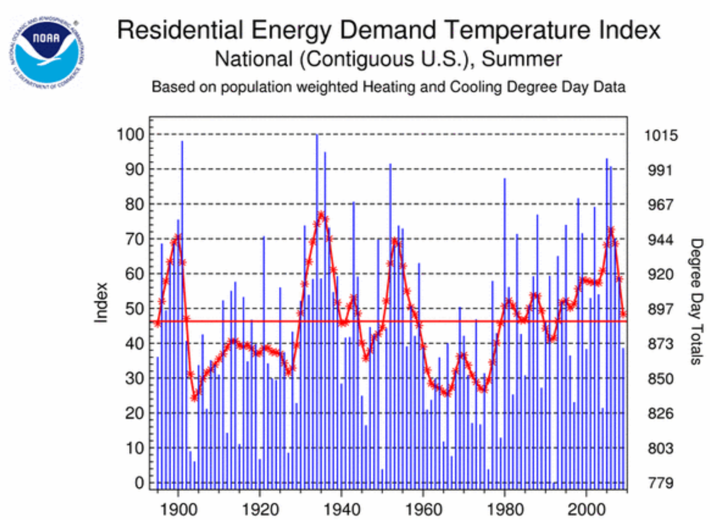
America's Energy Use – The Basics

In 2009 the United States consumed 94.6 quadrillion (946,000,000,000,000,000) British Thermal Units (BTUs) of energy to power our cars, homes, factories, stores, offices, etc. Each quadrillion BTUs are referred to as a *quad*. One quad is equal to about 300 billion kilowatt-hours of power. Some other key energy statistics include:

- 83 percent of America's energy supply comes from fossil fuels.
- The residential and commercial building sectors – which combined account for about 40 quads of energy consumed each year – have the greatest climate and weather related fluctuations in energy use. About 25 quads of this energy is used to generate electricity. Buildings being heated directly by natural gas, heating oil, coal, wood and other sources account for the remaining 15 quads. Temperature, humidity, wind, cloud cover and precipitation determine how much energy it takes to keep interior spaces lit and at comfortable temperatures.
- Even in the most efficient systems, some usable energy is lost during conversion and transfer. For example, out of the 25 quads of raw energy residences and businesses use to generate electricity, only about nine quads actually makes it to end users in the form of useable electrons. The rest of the energy (about 16 quads) is lost during the conversion and transfer.
- In the winter, energy is used to warm buildings; in the summer, energy is used to cool. Nationally, heating oil and natural gas use peak in the winter, while electricity use peaks during the summer when air conditioning use spikes. The exception is the Pacific Northwest, where most heat is produced by electricity, resulting in a wintertime electricity use peak.
- The transportation sector experiences a consumption increase during the summer months when Americans take to the roads for vacation and railway transport of coal peaks for peak electricity production. About 45 percent of America's rail freight tonnage is coal.
- The industrial sector's energy consumption varies little in relation to seasonal cycles or weather events.

HDDs, CDDs, and REDTI

Residential energy demand can be gauged by *degree-days*. A degree-day is the difference between a day's average temperature and 65 degrees Fahrenheit. *Heating degree-days (HDDs)* are measured when the temperature is below 65 degrees Fahrenheit. For example, if the day's average temperature was 55 degrees, the HDD would equal 10 (65 degrees – 55 degrees = 10 degrees). A month of similar conditions would mean HDD equals 300. *Cooling degree-days (CDDs)* work the same way, but are for temperatures over 65 degrees. An average temperature of 75 degrees would mean CDD equals 10. Geographic locations have different HDDs and CDDs. New York City, for example, has about 5,050 HDDs each year. The much colder climate of Barrow, Alaska has an average of 19,990 HDDs. See page three for a map of climate zones by HDDs and CDDs.



Above: The Residential Energy Demand Temperature Index for the summer season since 1895. Image Courtesy of NOAA/NCDC.

NOAA's Residential Energy Demand Temperature Index (REDTI) correlates heating and cooling degree-day data with population. A hot summer in sparsely populated Wyoming will not have the same impact on energy use as a hot summer in the Mid-Atlantic. June 2010 had the second highest REDTI on record due to especially hot temperatures in the heavily populated South and Southeast regions. The REDTI is measured on a scale of zero to 100, with 100 being the highest population weighted degree day average and zero being the lowest.

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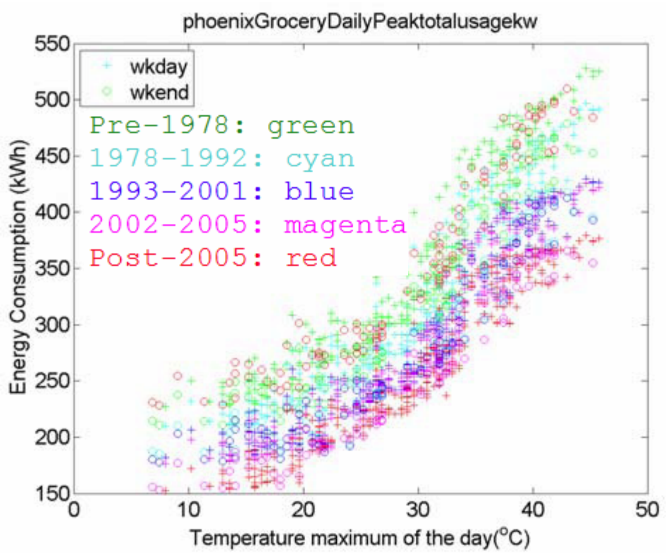
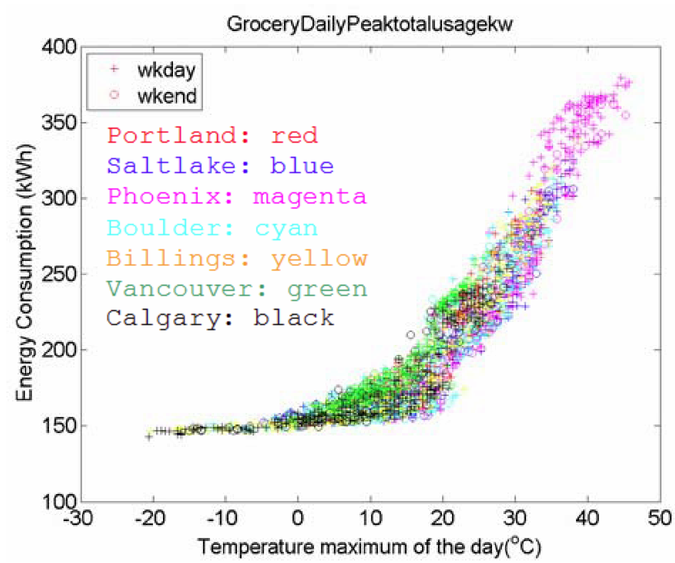
How Does Temperature Impact Energy Use in Different Sectors?

- ***Residential:*** A 1.6 degree Fahrenheit increase in average temperature decreases residential space heating needs by 6 to 10 percent and increases space cooling needs 5 to 20 percent. About 58 percent of residential energy use is for heating and cooling.
- ***Commercial:*** For commercial customers such as retail stores, a 1.6 degree Fahrenheit increase in average temperature decreases space heating needs by 7.4 to 9 percent and increases space cooling needs by 9.4 to 15 percent. About 40 percent of commercial energy use is for heating and cooling.
- ***Industrial:*** Despite weak relationships between weather and industrial energy use, weather may indirectly affect the sector as some industries reduce energy use during periods of peak power demand, which are influenced by weather. Many industries require lots of water for boilers and cooling systems and climate related fluctuations in water temperature may also influence industrial energy use. It takes less energy to bring 75 degree water to a boil than 70 degree water. It also requires more 75 degree water to cool a system than 70 degree water.
- ***Transportation:*** At highway speeds, running car air conditioning cuts down on fuel efficiency by 12 percent. Much of America's food supply is transported by refrigerated trucks or rail cars, and changes in temperature impact how much energy is required to keep foods cool. Currently, between 26 and 32 million barrels of diesel per year are used to keep truck-trailer refrigeration units running.
- ***Agriculture:*** Warmer temperatures lead to more evaporation and more water needed for irrigation. In the West, a significant fraction – about 9 percent in the Pacific Northwest – of the electricity load is used for irrigation. Livestock also must be kept warm during the winter and kept cool during the summer.





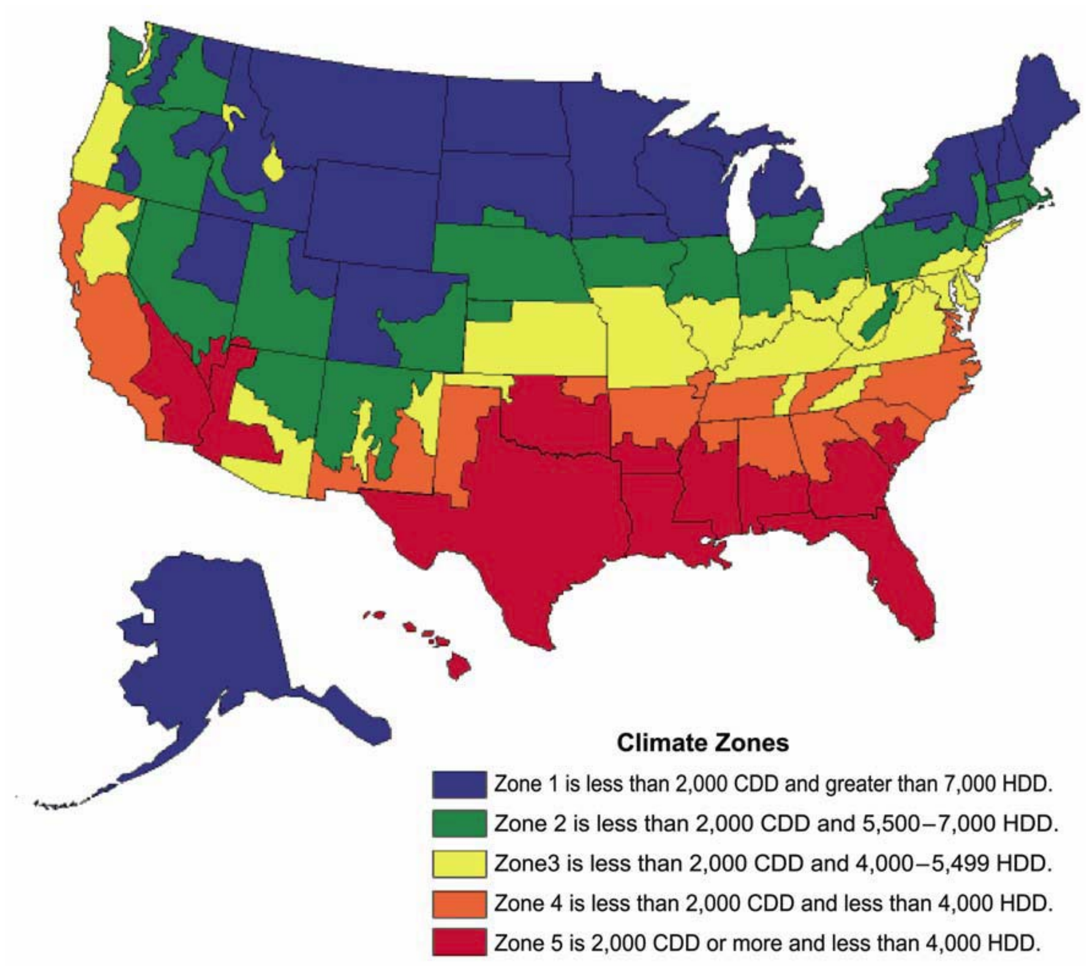
Images Above: Left –The relationship between maximum temperature and peak energy consumption at grocery stores in Phoenix, Arizona. Note how newer buildings generally demand less power. Right – The relationship between daily maximum temperature and peak power consumption at grocery stores across the West. Grocery stores spend lots of energy on refrigeration and refrigeration costs increase markedly with temperature. Image Courtesy of Department of Energy, Pacific Northwest National Laboratory.

Climate and the Electricity Transmission System – The Grid

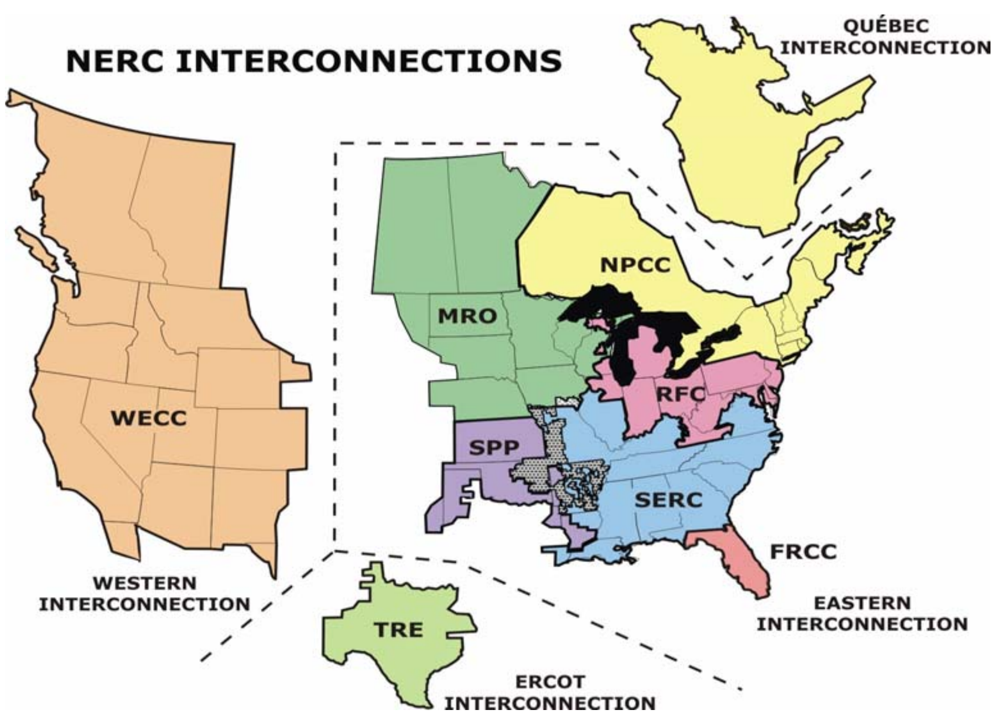
By altering energy demand, climate and weather also affect the electricity transmission system, known as *the grid*. Severe weather, such as high winds and ice storms can knock down power lines, causing blackouts. Shifts in climate can change when the peak electricity season occurs and cause problems for the grid. For example, the Northwest relies primarily on electricity for winter heating and has relatively mild summers, putting peak electricity consumption during the winter months. Conversely, the Southwest requires lots of electricity during the summer months to meet air conditioning demands. Hot summers can cause north and south regional peaks to overlap. The transmission of electricity through large power grids (see page three for a map of the interconnections) is critical to meet varying demands across the nation. When entire regions warm, meeting the electricity demand is challenging.

Cold Snaps

America consumes two trillion cubic feet of natural gas each winter. Natural gas heating degree-days have declined steadily over the past 50 years as, particularly since the 1990s, the Midwest has experienced fewer high-intensity cold events. Geographic distributions of cold-snaps also affect energy consumption. Residents of Atlanta, for example, are generally not acclimated to cold weather and do not own many cold weather clothes. This means that they tend to "crank-up" the heat during severe cold outbreaks to an extent that people in more northern cities going through similar temperatures would not. On the other hand, improved insulation in many newer homes and businesses means that less energy is needed to respond to cold snaps today compared to several decades ago.



Above: America's climate zones demarcated by the number of Heating and Cooling Degree-Days per year. Image Courtesy of the Energy Information Administration.



Above: Discrete regions of electricity transmission as delineated by the National Energy Regulatory Commission (NERC). Image Courtesy of NERC.

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