



Earth Gauge

A National Environmental Education Foundation Program

Climate Variability and Renewable Energy Resources

The Status: Renewable energy is energy that can be replenished in a reasonable amount of time. On the other hand, fossil fuels like coal and oil exist in finite supplies that take hundreds of millions of years to create. Most (86 percent) of the energy that powers America comes from fossil fuels. Renewable sources account for only about six percent of this energy and nuclear – which is based on finite supplies of a mineral called uranium – accounts for eight percent. This dependence on depletable sources of energy is prompting many to consider renewable sources to create a sustainable energy system and prevent increasing energy costs over the long-term.

The Trends: Investments in renewable energy in the U.S. are increasing. In the past ten years, America's installed wind power capacity has gone from less than 2,500 megawatts to almost 29,000 megawatts – more than a 1000 percent increase. Trends in solar power installation, in the form of photovoltaic panels, concentrating solar power plants, houses that use passive solar for heating, solar water heaters, etc., have also been robust, with the photovoltaic installation trends comparable to those for wind turbines. If these trends continue, renewable energy sources will be a far more important component of America's electricity portfolio within a few decades.

The Challenges: Wind and solar are variable power sources – their operation depends on the weather and the time of day. Power companies must match supply with demand on a minute-by-minute basis, as America currently lacks the means to effectively store large amounts of electricity. This creates a “use it or lose it” scenario. Lack of storage ability is particularly problematic for renewable energy, as there is no guarantee that the wind will blow strong or the sun will shine bright when people want electricity the most. Because it can take a day to power up a coal plant, these plants are often left running as back-up just in case there will be sudden jumps in power demand or sudden drops in wind or solar energy. Running these back-up plants consumes energy that is not used, known as “spill” energy. Improvements in forecasting, particularly on shorter zero- to six-hour timescales, can give utilities the information they need to make more cost effective decisions. If strong winds that will provide plenty of wind power are forecasted, utilities can turn down back-up power plants, saving fuel and money. Much work remains to be done on improving renewable energy supply forecasts: solar energy forecasts, for example, often have more than 20 percent uncertainty on short time scales, due primarily to uncertainties in cloud cover. Forecasts of average annual solar energy have seven percent uncertainty.

Here, learn more about how weather and climate can affect solar, wind and hydroelectric power generation.

SOLAR

Solar plants operate best on direct sunlight. Clouds and hazy conditions mean less energy reaches the Earth's surface. The map to the right illustrates long-term averages in solar energy potential (red areas are best at generating solar power and blue areas are worst). The desert Southwest has the most potential to generate solar power. Rainier regions and areas farther from the intense equatorial sun have less potential. Dust storms also affect solar generation because they block out sunlight. Dust can also accumulate on solar installations, impeding their effectiveness. Severe weather, such as wind and hail storms, can physically damage solar generation equipment.

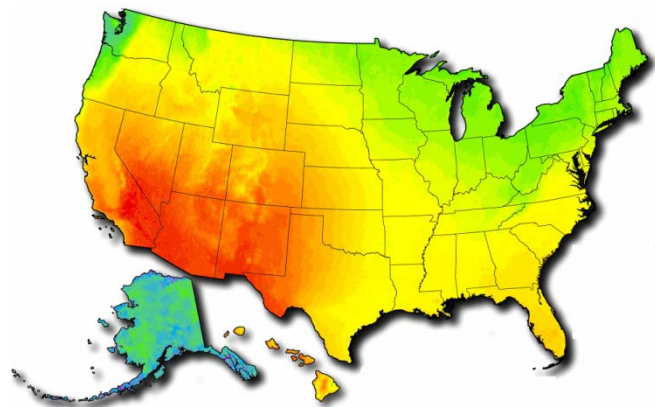


Image courtesy of National Renewable Energy Laboratory

One type of solar-power generation, concentrating solar power (CSP), is arguably more efficient than traditional photovoltaic systems, but current designs require lots of water to function. The areas of the United States where solar power can be produced most efficiently (the Southwest) are also the areas where water resources are under the most stress. Fires, as well as other pollution sources, create haze that reduces surface solar intensity. Both fires and droughts have been linked to conditions in both the Atlantic and Pacific oceans. Warm surface conditions in the North Atlantic, for example, correspond to less precipitation in the West, which means less water for solar installations as well as more wildfires (see next page for more info on climate variability).

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WIND

Winds moving from west to east pick up speed over the Rocky Mountains before descending onto the relatively flat Great Plains. Known as America's "wind corridor," this region is considered one of the best spots for building wind turbines on a large scale. America's West Coast and the mid-Atlantic and Northeast shores also have potential for wind development, as do the Great Lakes.

The map to the right illustrates America's 50-meter (164 foot) wind potential – winds are stronger, more consistent and less turbulent at this height. According to the National Renewable Energy Laboratory, "class three" wind areas have annual average wind speeds of greater than 14.3 miles per hour (mph). The energy production from a wind turbine is roughly equal to the cube of the wind speed. For example, a reasonably well-functioning wind mill with a blade area of about two yards can produce 100 watts with 15 mph wind; if wind strengthens to 18 mph (20 percent increase), the mill can generate over 150 watts (50 percent increase). This means that even small wind forecast errors can result in large energy production forecast errors, highlighting one way renewable energy is dependent on accurate forecasting.

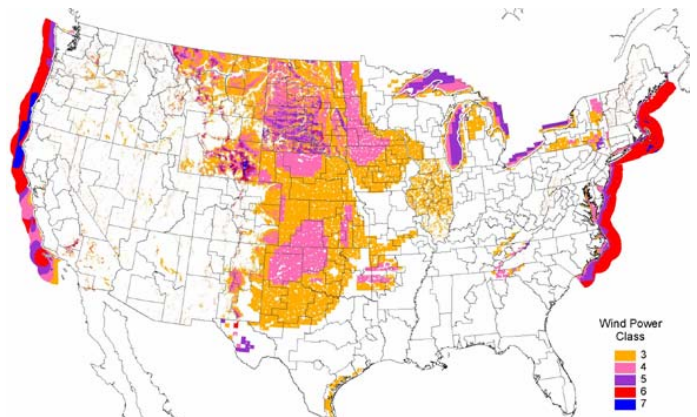
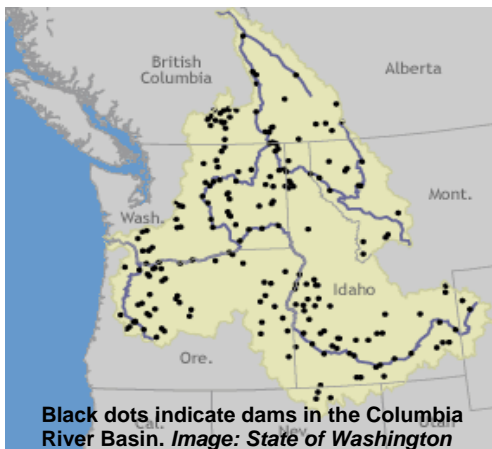


Image courtesy of National Renewable Energy Laboratory

HYDROELECTRIC POWER



Hydroelectric power is an important electricity source in the western United States. Most of the Pacific Northwest's electricity comes from dams, and reservoir levels there are tightly coupled to climate variability. Unlike the East, where there is little precipitation seasonality, most annual precipitation in the West falls during the winter months. Much of this precipitation falls as snow, creating snowpack. This snowpack serves as water storage before melting in the spring and summer months and flowing into reservoirs. High snowpack and late spring melt result in reservoir levels that can produce a reliable power supply. Currently, 75 percent of the West's water originates as snowmelt. If climate changes this fraction, hydroelectric power may become more difficult to manage as a reliable source of electrical energy. For example, more winter precipitation falling as rain instead of snow may overwhelm the dams during winter, forcing water to be discharged into the oceans instead of saved for the summer months.

RENEWABLE ENERGY AND CLIMATE VARIABILITY

Both wind and solar amounts vary on time scales from minutes to decades. Understanding these variations, both short-term weather changes and longer term climate variability, will be important to making full use of renewable energy and planning for energy sources of the future. Some climate/renewable energy connections include:

ENSO and Solar Variability: The warming and cooling of the eastern Tropical Pacific on a period of two to seven years, known as the El Niño-Southern Oscillation (ENSO), affects circulation in the upper atmosphere, which affects the storm tracks that influence America's weather. ENSO's effects vary from season to season. In the Southwest, warm ENSO phases mean rainy and cloudy winters, reducing solar production. On the other hand, they also mean suppressed Southwest summer monsoons, increasing solar availability during the summer months. Since the 1970s, El Niño phases have become more common than La Niña phases.

Wind Power and Climate: Years of "low-wind" in the northern Great Plains/southern Canadian prairie region usually coincide with moderate to strong El Niño years. On the other hand, El Niño years also mean fewer sub-zero winter days in the region. Wind turbines cannot be operated without equipment damage once temperatures drop to around zero degrees Fahrenheit. Over the last 50 years, most of the western United States and sections of the wind corridor experienced a decline in the number of cold winter days (days falling in the lowest ten percent of the daily mean surface temperature distribution). Observations indicate a small decline in America's average wind speed since the 1970s, with the greatest declines occurring in the East and Midwest.

Precipitation in the West: Across the West there has been an 11 percent decline in overall snowpack over the last 50 years and rivers are reaching their peak flow 10-40 days earlier than they did in the 1950s. This trend means lower summertime flows, making hydroelectric power more difficult to manage and less reliable, and reduces the water available for concentrating solar power. This decline in snowpack can also lead to more intense fire seasons in the West. More fires mean more haze and less solar energy at the surface. Six of the last ten fire seasons have been classified as severe, with more than 2.8 million hectares burned during each severe season.

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