FOCUS STUDY 4.1

Wind Power: An Energy Resource for the Present and Future

The principles of wind power are ancient, but the technology is modern and the benefits are substantial. Scientists estimate that wind as a resource could potentially produce many times more energy than is currently in demand on a global scale. Yet, despite the available technology, wind-power development continues to be slowed mainly by the changing politics of renewable energy.

The Nature of Wind Energy

Power generation from wind depends on site-specific characteristics of the wind resource. Favorable settings for consistent wind are areas (1) along coastlines influenced by trade winds and westerly winds; (2) where mountain passes constrict air flow and interior valleys develop thermal low-pressure areas, thus drawing air across the landscape; and (3) where localized winds occur, such as an expanse of relatively flat prairies, or in areas with katabatic or monsoonal winds. Many developing countries are generally located in areas blessed by such steady winds, such as the trade winds across the tropics.

Where winds are sufficient, electricity is generated by groups of wind turbines, in wind farms, or by individual installations (Figure 4.1.1). If winds are reliable less than 25%–30% of the time, only small-scale use of wind power is economically feasible.

(a)

(b)

FIGURE 4.1.1 Kansas wind farm.
(a) The Gray County Wind Farm, 40 km (25 mi) west of Dodge City, Kansas, generates 112 MW of electricity. All the towers and roads combined occupy only 6 acres of land, allowing 12,000 acres to stay in agricultural production. (b) Wind turbines on Ascension Island, 8° S latitude. Only four of the turbines in the right-hand photo offset the importation of 300,000 barrels of oil. [Bobbé Christopherson.]

The potential of wind power in the United States is enormous (Figure 4.1.2). In the Midwest, power from the winds of North and South Dakota and Texas alone could meet all U.S. electrical needs. In the California Coast Ranges, land–sea breezes blow between the Pacific and Central Valley, peaking in intensity from April to October, which happens to match peak electrical demands for air conditioning during the hot summer months.

On the eastern shore of Lake Erie sits a closed Bethlehem Steel mill, contaminated with industrial waste until the site was redeveloped with eight 2.5-MW wind-power turbines in 2007 (Figure 4.1.3). This former "brownfield" site now supplies the equivalent of 75% of the electricity for Lackawanna, New York. Twelve turbines will soon be added, making this a 50-MW electrical generation facility, the largest urban installation in the country. An additional proposal for 500 MW of wind power from some 167 turbines is in the works for an installation offshore in Lake Erie. This former steel town is using wind power to lift itself out of an economic depression with the slogan "Turning the Rust Belt into the Wind Belt."

While most U.S. wind power is land-based, offshore wind development has high potential. The proposed Cape Wind Farm near Cape Cod, Massachusetts, was recently approved as the nation's first offshore project. Proponents hope that despite the additional expense, offshore production will increase, especially along the eastern seaboard, where population centers are close together. At least 12 offshore projects are currently under consideration, most of them on the East Coast.

Land-based wind-power development is enhanced by the income it brings. Farmers in Iowa and Minnesota receive about $2000 in annual income from electrical production by a leased turbine and about $20,000 a year from electrical production by an owned turbine—requiring only one-quarter acre to site the wind machine. The Midwest is on the brink of an economic boom if this wind-energy

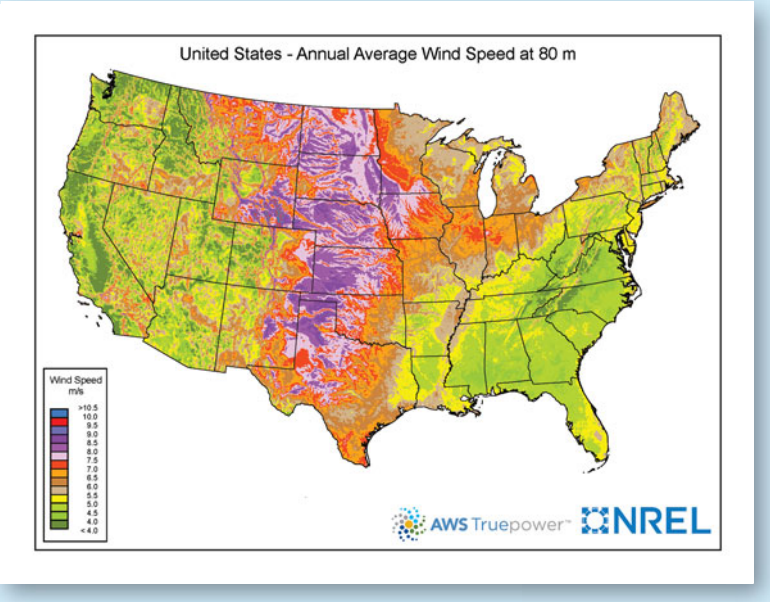

FIGURE 4.1.2 Annual average wind speed map of the United States. Wind speeds measured at 50 m (164 ft) indicate the potential for wind-power generation at a spatial resolution of 2.5 km. [NREL and AWS Truepower.]

FIGURE 4.1.3 Wind turbines at a former industrial site on Lake Erie. Known as "The Steel Wind," eight turbines deliver 20 MW of wind power in Lackawanna, New York, on the eastern shore of Lake Erie, south of Buffalo. [Bobbé Christopherson.]

potential is developed and transmission line capacity installed. In fact, Iowa now ranks second for installed wind-power capacity in the United States.

Wind-Power Status and Benefits

Wind-generated energy resources are the fastest-growing energy technology—capacity has risen worldwide in a continuing trend of doubling every 3 years. Total world capacity approached 190,000 MW (megawatts), or 190 GW (gigawatts), by the end of 2010 from installations in 81 countries. Globally, the wind-power industry employs more than 550,000 people, with global investments passing the U.S.$63 billion mark in 2009. Forecasts state that employment will top the million-worker mark in 2012. Average-size wind farms produce more than 100 MW.

In the United States, installed wind capacity exceeded 40,180 MW through 2011, an increase of 300% in 4 years. Installations are operating in 37 states, with the most capacity in Texas, Iowa, California, Minnesota, Washington, Oregon, and Illinois. This puts U.S. installed wind capacity second highest on a global level behind China's 41,800 MW, with Germany third.

The European Wind Energy Association announced installed capacity exceeding 84,000 MW at the end of 2010. Germany has the most, followed by Spain, Italy, France, and the United Kingdom. The European Union has a goal of 20% of all energy from renewable sources by 2020.

The economic and social benefits from using wind resources are numerous. With all costs considered, wind energy is cost-competitive and actually cheaper than oil, coal, natural gas, and nuclear power. Wind power is renewable and does not cause adverse human health effects or environmental degradation. The main challenges of wind-generated power are the high initial financial investment required to build the turbines and the cost of building transmission lines to bring electricity from rural wind farms to urban locations.

To put numbers in meaningful perspective, every 10,000 MW of wind-generation capacity reduces carbon dioxide emissions by 33 million metric tons if it replaces coal or by 21 million metric tons if it replaces mixed fossil fuels. As an example, if countries rally and create a proposed $600 billion industry by installing 1,250,000 MW of wind capacity by 2020, that would supply 12% of global electrical needs.

Whether or not governments and transnational energy corporations support full-scale implementation of renewable resources such as wind, the energy realities of the near future leave no alternative, and global political realities affirm this urgency. By the middle of this century, wind-generated electricity could be routine, along with other renewable energy sources, conservation, and energy efficiency.