Photos by Jacqueline's Portraits, Ames; courtesy Iowa Energy Center

PART ONE: AN OVERVIEW

Does wind power make sense for you?

BY WILLIAM G. HAMAN, P.E.

Iowa's rural landscape once was dotted with multi-bladed windmills at every family farm. Installed to pump water for livestock or charge batteries for home lighting, these timber-bladed windmills began to lose favor during the 1950s—after rural electric cooperatives proved they could deliver safe and reliable power for electric pumps, lights, radios and kitchen appliances.

Today, wind turbines—updated versions of those time-honored windmills—are popping up all across the state. You've probably seen them spinning in the distance while traveling down the highway in the northwestern quadrant of the state—or perhaps you've spotted one at a local business, area school or even a neighbor's property.

But even if you haven't seen a wind-generating system up close, a question likely still remains in your mind: Is this renewable energy technology with deep roots in the past appropriate for your electric energy needs today?

Revisit science class

Wind energy is the kinetic energy of large masses of air moving over the earth, and it's a byproduct of solar energy. Approximately two percent of the solar energy reaching the earth is converted to wind, through the uneven heating of the earth's atmosphere and surface. This uneven heating creates atmospheric pressure gradients that cause the air masses to move from areas of high pressure to areas of lower pressure, creating wind. Wind turbines convert this kinetic energy into usable mechanical and electrical energy.

The quantity of energy that can be extracted by a wind turbine is a function of air density, wind velocity and the turbine's efficiency.

- Air density impacts potential power since it increases with lower ambient air temperatures and surface elevations. In Iowa, seasonal temperature changes can influence power availability by as much as 25 percent.
- Wind velocity is the most sensitive component of the wind power equation; small changes in wind speed can have a significant effect on the amount of available wind power. Power derived from wind is a function of the wind velocity cubed. To illustrate, increasing the wind velocity from 10 mph to 12.6 mph (a 26 percent increase) doubles the wind power potential.
- The wind turbine's efficiency generally is supplied by its manufacturer and is dependent on the turbine's design and operating characteristics.

Everyone knows it's windy

Iowa contains some of the world's most fertile land for harvesting grains, as well as some of the country's greatest wind resources. In fact, Iowa's wind energy development ranks third in the U.S., and the state is home to one of the world's largest wind farms (near Alta).

Most Iowans think that the wind always blows where they live, and many of them claim that they reside on the windiest parcel of land in the state. In truth, the winds don't blow steadily (or at the same intensity) all year long, and—according to the National Renewable Energy Laboratory—Iowa is only the tenth-windiest state in the nation. As a result, the uncertainties associated with the availability of wind make wind turbines a sometimes unreliable source of power.

Between 1994 and 1999, grantees of the Iowa Energy Center (IEC) extensively researched wind resources in Iowa to map high-quality wind data suitable for wind energy planning purposes. This data is available on IEC's Web site (www.energy.iastate.edu), along with an interactive calculator that permits you to predict, at a feasibility level, the wind resources and wind turbine energy generation potential at any location in Iowa.

In general, the greatest wind resources correspond to the highest surface elevations. Iowa's northwest and north-central regions contain the greatest wind resources; the winds diminish as you travel east and southeast.

The magnitude of wind speed at a given location is influenced by geological events that occurred 10,000 years ago. As the glaciers descended across the upper Midwest and into Iowa, the Des Moines Lobe extended approximately from the Loess Hills in the west to Interstate 35 on the east and Highway 30 on the south; the glaciers also helped form the Buffalo Ridge in northwestern Iowa and the Radcliffe Ridge in north-central Iowa. As the glaciers receded, deposits measuring thousands of feet deep were left behind and between these ridges. This event raised the elevations of northwest Iowa relative to the rest of the state and improved the wind resources in these areas.

Wind speeds also are influenced by local topography and weather patterns.

The Forest City School District's utility-scale wind turbine shadows both the high school's football field and secondary school's playground.

For example, you can expect to find higher wind speeds at the top of a hill or ridgeline versus a valley, on the windward slope of a hill rather than the leeward slope and over flat and clear land versus heavily timbered or developed land. But regardless of location in Iowa, the highest wind speeds occur during the spring and fall months, while the calmest winds occur during the "dog days of summer."

How much do you need?

A typical residential home in Iowa consumes an average of 700 to 1200 kilowatt-hours per month. Check your usage by looking at your power bills for the last year, or call your local electric cooperative for the information.

Choosing a wind turbine to meet your electricity needs depends on the average wind speeds at your location. A residential wind turbine needs winds of about eight miles per hour before it begins generating power.

Small wind turbines suitable for residential installations are available in several sizes up to 10 kilowatts; this size has become the norm for typical residential applications that will be connected directly to the local power grid. A typical 10-kilowatt wind turbine operating in an area having average annual wind speeds of 15 mph can generate approximately 23,600 kilowatt-hours annually. Turbines larger than 10 kilowatts—and more suitable for small farm applications—are available in 20- and 50-kilowatt sizes.

NEXT MONTH:
More details on setting up a wind turbine at your place

And here's something else to consider: Since wind speed increases with elevation, wind turbine tower height is a significant issue. The incremental cost associated with a marginally taller tower may reap significant energy generation benefits during the life of a wind turbine.

Call your electric co-op first

Although wind turbines may be installed independently of the electric power grid (normally to power banks of storage batteries), grid-interconnected systems allow the best of both worlds: wind-generated energy consumption during windy periods and the reliability of electric grid power during calm periods.

If you're considering the construction of a wind turbine interconnected with the electric grid, contact your local electric cooperative during your

planning stages. All grid-interconnected projects need to be compatible with the local distribution system and must meet your co-op's specifications for safety and reliability.

Here's the bottom line

Wind turbine costs vary, depending on the size and output of the equipment you choose. The price of a smaller residential wind turbine system ranges between $2,000 and $2,500 per kilowatt, so a typical 10-kilowatt wind turbine system might cost between $25,000 and $30,000 installed. In addition, you should evaluate future (and recurring) costs for normal maintenance and insurance, as well as any upgrades to the lines that will need to be made before you can connect to the power delivery system.

The Alternate Energy Revolving Loan Program administered by the Iowa Energy Center is a financial incentive program created by the Iowa legislature in 1996 to encourage the construction of renewable energy projects. The program offers one-half of the financed project costs up to $250,000 at zero percent interest for a term not to exceed 20 years. For more information regarding the program, check the IEC Web site at www.energy.iastate.edu.

Is wind power right for you?

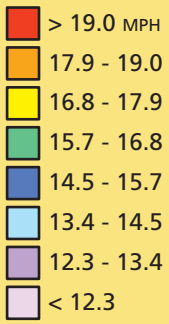
Before you can answer this question, you must analyze two key elements: the wind resources at your site and the economics of the project. For example, if you live in an area of great wind resources combined with low energy prices, setting up a wind system might be less attractive to you than for someone living in an area with moderate wind resources and higher energy costs.

The majority of Iowans reside in areas that bridge these two extremes, which makes an economic analysis not altogether intuitive. Although electric utilities are required by law to purchase any excess power generated from a wind turbine, the greatest benefit you'll derive from owning a wind system is displacing (or at least greatly reducing) your monthly power bill.

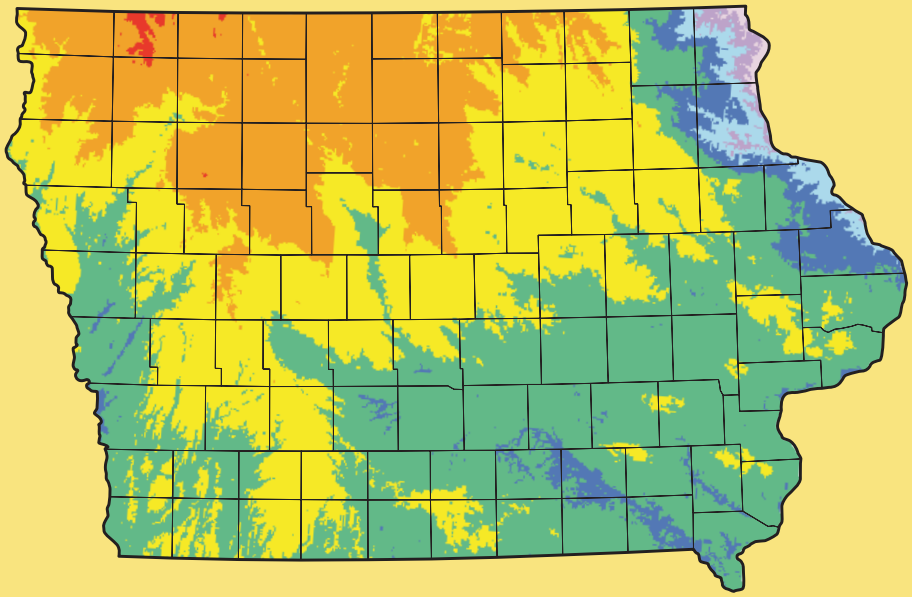
William G. Haman is the Industrial Program Manager and the Alternate Energy Revolving Loan Program Manager for the Iowa Energy Center.

Iowa wind maps

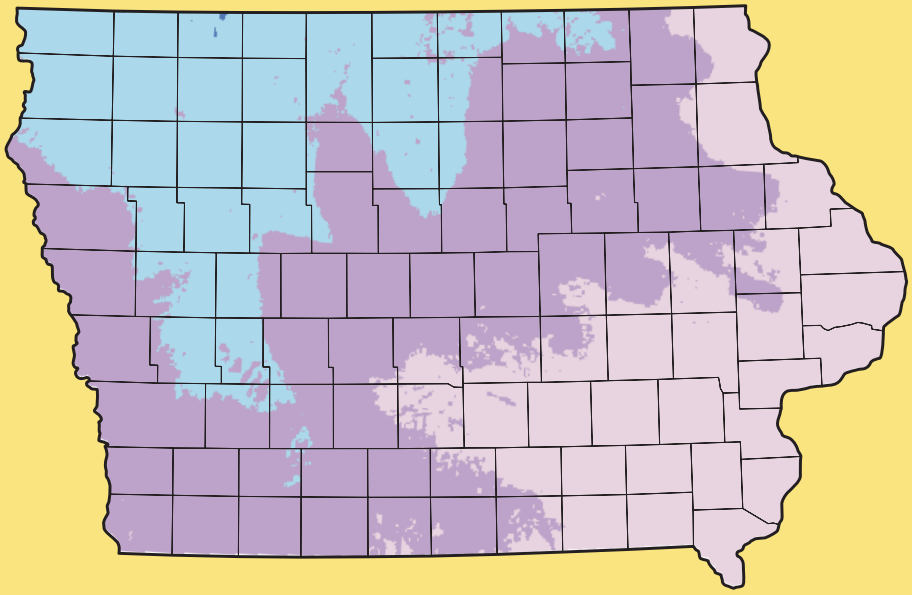
These wind maps from the Iowa Energy Center illustrate two points that need to be considered when studying wind power development. First, the magnitude of wind is not steady throughout the year. In fact, wind speeds from October through May are significantly higher than they are from June through September. Second, the windiest parts of the state are always in the northwest and north-central regions. Developing wind power outside these areas requires a higher value on the energy generated in order to maintain a similar economic payback.



March (Typical average wind speeds on well-exposed sites at 165 feet above ground)



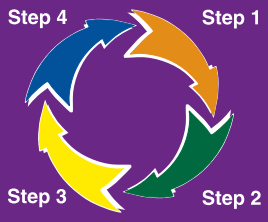
August (Typical average wind speeds on well-exposed sites at 165 feet above ground)



Does wind power make sense for you?

Call your electric co-op first for help

Regi Goodale, director of regulatory affairs for the Iowa Association of Electric Cooperatives, offers this advice to people thinking about investing in a wind-power system: "Make sure you know what you're getting into. Have a pretty good sense of the complete picture before cutting a check for a wind turbine that has costs you maybe didn't know about."



Step 1: Contact your cooperative to arrange a meeting.
Step 2: Meet with your cooperative to verbally express intentions.
Step 3: Work with your cooperative to develop a written agreement.
Step 4: Proceed as outlined in the written agreement.

Representatives of your electric cooperative can assist you in identifying the costs of connecting a wind turbine to the utility's grid. Goodale strongly suggests that anyone considering the installation of a turbine meet with a co-op adviser before making a turbine purchase.

"The co-op will need information such as location, size and how the system will be interconnected to the grid," says Goodale.

In fact, he says, connecting a wind turbine to the utility's grid involves ensuring both safety for the utility's employees and the reliability of the flow of electricity to the co-op's other customers.

When a privately owned wind turbine is connected to an electric co-op's power grid, it automatically pushes the owner's unused kilowatts back into the system. If those kilowatts are being fed into the system at the same time the cooperative's linemen are working on lines they believe to be de-energized, the electricity can electrocute them. As a precaution, utilities typically require the owner of a wind turbine to install a safety switch before granting a customer access to the grid. In addition, the private owner is responsible for obtaining and paying for permits, inspections, easements, insurance and other startup costs.

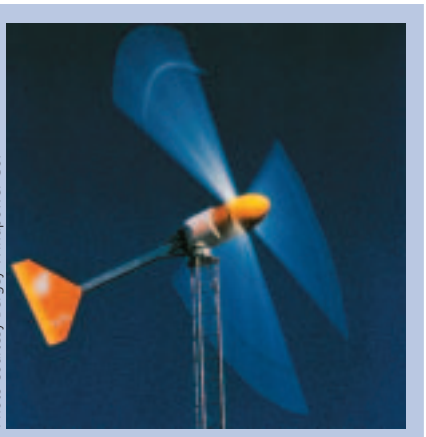


Photo courtesy Bergey Windpower Co.

What's the hardware cost?

There are two numbers you should consider when evaluating a wind turbine system: the *initial investment* for hardware and installation and the projected *payback*. The 10-kilowatt turbine shown here would cost about $30,000 (including the tower and wiring)—plus installation. That means your payback on this system could take about 8-15 years (not including maintenance costs), depending on the cost of energy from your electric co-op.

Wind farms are big business

The local electric cooperative that sells you electricity is a distributor of that electricity, but it doesn't generate the electricity. Iowa's electric co-ops buy the power they sell you from generation cooperatives in Iowa, Missouri, Wisconsin and North Dakota.

So, local electric cooperatives are not in the market to lease fields from farmers wanting to "plant" wind turbines on their properties and generate wind power as a cash crop—because these co-ops are not in a position to generate their own electricity.

Photo courtesy Iowa Energy Center

Wind turbines at the Cerro Gordo wind farm near Clear Lake tower over the surrounding farm fields.

The land that is home to wind farms located in the state usually is not leased by utilities at all, but by companies in the business of generating wind power and then making deals with utilities to buy it.

How much will an electric co-op pay you for wind-generated power?

As required by federal law, a local electric cooperative will purchase the excess power generated by a member/consumer's wind power system—over and above the amount of wind-generated energy he or she consumes. The cooperative will purchase the excess power at a rate comparable to what the co-op's power supplier would incur if comparable power were generated by the power supplier or purchased from another source.

Here's the voice of experience

Jeff Matt of Shell Rock likes to joke that climbing up and down the tower of his $25,000 wind turbine keeps him slim and fit, the way a treadmill or exercise bike would for people with less-expensive "hobbies."

"It's something I enjoy doing," says the self-described "techie," who works by day for John Deere. "I've built it and made it work. I bought it as sort of an Erector Set for the challenge of it. It isn't for somebody who can't maintain it on their own."

A wind-generating system is also not for someone who's looking to make a killing by selling some of the electricity the turbine produces back to a local electric cooperative, warns Matt. He earns about two cents per kilowatt-hour from the co-op's power supplier on windy days when his turbine produces more electricity than he can use at home, an amount that doesn't add up to much when he calculates the cost of installing and maintaining the system.

Instead, he profits when the wind turbine produces enough electricity to power his home without any help from his co-op, Butler County Rural Electric Cooperative in Allison. Matt estimates that his electric bill—about $120 a month pre-turbine—is down to less than $50 a month now. He still draws electricity from the electric cooperative on days when the wind doesn't blow—which he says is typical in January and all summer long.

Do your homework before you buy

The Iowa Energy Center's Web site (www.energy.iastate.edu) is a valuable resource for learning about the wind energy potential at your location. (On the main menu, go to Renewables and click on Wind.)

The Web site contains a Wind Energy Manual with lots of background information on wind generation; Iowa Wind Maps that show when, where and how strongly the winds blow across the state; and an interactive Wind Assessment Study and Wind Turbine Output Calculator that will help you evaluate different wind power systems for your area.

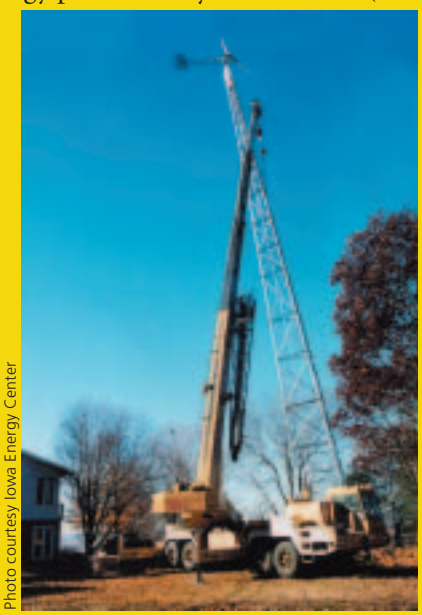


Photo courtesy Iowa Energy Center

A crane operator was hired to position the wind turbine and tower at this residence in the southwest corner of Iowa. The homeowner received a low-interest Alternate Energy Revolving Loan Program loan to help fund the construction of the wind-power system.

- The **Wind Energy Manual**, written for the wind energy novice, provides basic information about wind energy development. In addition to a brief history of wind power and the fundamental physics involved, the manual provides information concerning legal, social, environmental and economic issues associated with wind power. The manual also includes a listing of wind power equipment manufacturers, consultants, organizations and government agencies.
- The **Iowa Wind Maps** are the culmination of a six-year Iowa Energy Center project to assess the wind resources in Iowa. The color-coded maps provide the average wind speeds across the state on an annual and monthly basis. The maps, among the most comprehensive of their kind in the country, show the wide variations in wind speeds across different parts of the state.
- The **Wind Assessment Study and Wind Turbine Output Calculator** is an interactive tool that enables you to estimate the energy generation you might expect from a wind turbine located at any site in Iowa. The calculator combines wind speed data with many wind turbine manufacturers' power output curves to calculate the projected energy generation on a monthly and annual basis for an average year. The calculator allows you to input a location, a wind turbine (from a long list), any turbine tower height and a subjective measure of the site's topography. You can compare the calculator's output against your actual electricity usage (as recorded on your monthly utility bills) to determine whether the selected wind turbine may satisfy your needs. The intent of the calculator is to provide you with enough information to determine whether further investigations into a wind power system are warranted.

For more information, look at these Web sites

- Iowa Energy Center: http://www.energy.iastate.edu
- Iowa Association of Electric Cooperatives: http://www.iowarec.org
- American Wind Energy Association: http://www.awea.org
- U.S. Department of Energy: http://www.eere.energy.gov/RE/wind.html
- For more information and a list of wind turbine companies, search "wind power," "wind energy" or "wind turbine" on Google or Yahoo.

How a wind turbine system works

This drawing depicts the basic elements of a wind turbine generating system interconnected to a utility's electric grid. The configuration may vary, depending on the turbine owner's location and equipment—as well as code requirements and the electric cooperative's policies.

Wind Turbine
A wind turbine sized to meet the needs of a typical family begins generating direct current (DC) power at wind speeds of about 7-10 miles per hour. That power is sent by wire to the inverter.

Power Plant

Step-Up Substation

High-Voltage Transmission Lines

Transmission Substation

Large Industrial User

Local Distribution Substation

Farms

Homes

Tower
The tower supports the turbine high enough (generally 80-120 feet) to avoid turbulence created when the wind flows around nearby structures and trees.

Turbine Cut-Off Safety Switch
To ensure the safety of linemen working on power lines during outages and maintenance projects, the electric co-op must have unimpeded access to an emergency/safety switch that isolates the wind turbine system from the co-op's lines. This switch disconnects the wind turbine system, so it won't accidentally send power to lines that the linemen believe are de-energized. This switch is also used during regular maintenance or repairs of the turbine by its owner.

Inverter
The inverter converts the direct current (DC) supplied by the wind turbine to alternating current (AC) used in the home's circuits.

Circuit Breaker Panel

Metering System
The metering system may include one meter with two displays or two separate meters. One measures the electric cooperative's power being used in the home; the second measures the excess power generated by the wind turbine system that is not being used in the home and is flowing to the electric co-op's power lines.

Iowa's Local Electric Cooperatives