Wind and Sun and Farm-Based Energy Sources

STEPHEN AUSMUS (D567-1)

What do Minnesota, Texas, and Alaska have in common? They all contain remote areas and get lots of wind.

Texas and Minnesota are striving to become leaders in renewable energy use—relying on everything from wind power to hydrogen fuel. ARS researchers have been working closely with university scientists, industry, and landowners in those states to develop renewable energy.

In just 20 years, companies have installed so many new wind turbines that the United States' ability to "farm the wind" for electricity increased more than 900-fold—from 10 megawatt hours annually in 1981 to 9,149 megawatt hours as of January 2006. Texas and Minnesota are among the top five states producing wind energy.

Wind power today is generated by turbines that use only two or three very long, sleek blades, unlike the quaint, multibladed windmills that once symbolized the West. A turbine's size depends on whether it is to be used for "wind farms"—clusters of 50 to 200 wind turbines producing power to sell to electric companies—or for individual farms and homes or entire remote communities far from a power grid.

Turbines in wind farms are set on towers 230 feet or more high, in areas with winds of 17 miles per hour or more. These are huge machines, about the size of a Boeing 747 airplane, says Nolan Clark, director of the ARS Conservation and Production Research Laboratory in Bushland, Texas. Each can produce enough electricity to power more than 500 average homes.

Wind farm companies pay farmers and landowners about $3,000 per tower per year, and towers are spaced about every 100 acres.

Lighting a Cold Place, Far Away

The ARS Renewable Energy and Manure Management Research Unit headquartered in Bushland has designed a wind-diesel hybrid control system for two remote Alaskan fishing villages to reduce their dependence on diesel-fueled generators for electricity. The generators are linked to wind turbines by a computerized system that seamlessly switches between diesel and wind without interruption. ARS scientists worked with manufacturers of wind turbines and of diesel engine controls. The computerized control system is commercially available.

Says Clark, "We reduced energy costs from 48 cents to 28 cents a kilowatt hour for one village—saving both diesel fuel and storage costs. Last year, when diesel prices went up, some villages had to spend an extra $10,000 to buy a year's supply of fuel."

The Bushland scientists worked with the Alaska Village Electric Cooperative and the Alaska Energy Authority to install these systems. Several more villages are interested in adopting the system, and still another adopted the scientists' suggestion to mix fish oil with diesel. Generators can run on biodiesel made from a variety of plant or animal fats and oils. In remote areas, local sources—such as fish oil in Alaska or palm oil in Hawaii—are generally the most economical.

Meanwhile, in Sunny Texas

In Alaska, there isn't enough sunlight for solar power to be a part of hybrid systems. But in Texas there is. So the Bushland team designed their hybrid system with solar power included. They design and test wind/solar/biodiesel hybrid systems running an experimental electric grid.

They also use solar energy to power electric pumps for irrigation and for filling water troughs for cattle in remote locations on open range. These regular pumps can be run on solar power thanks to a computerized control device the team built.

They have also designed and tested pumps specifically made to run on solar power. One such pump has been commercialized, and Bushland researchers are working with three pump companies to design more.

"We feel good when we drive down the road and see our pumps being used by farmers," says Clark.

They also use wind turbines to operate water pumps and for wind-farm research with the U.S. Department of Energy.

To compare the cost-effectiveness of wind power versus solar power—or both—to operate water pumps, Clark's team places a small wind turbine by each pump. So far, it's not been cost-effective to have both wind and solar systems. Solar power has worked best for pumping up water from less than 100 feet deep,

STEPHEN AUSMUS (D569-1)

Above: Agricultural engineer Nolan Clark (center) and technician Anthony May (kneeling) prepare a microturbine for operation with a wind-hybrid system for supplying electric power to remote villages while agricultural engineer Byron Neal measures emissions from a diesel generator.

Right: Renewable-energy team members prepare experimental wind turbine blades for atmospheric testing. Team members pictured are ARS agricultural engineers Byron Neal (left foreground) and Nolan Clark (right foreground), and, from Sandia National Laboratories, electrical engineer Mark Rumsey and technician Donny Cagle (background).

NOLAN CLARK (D-570-1)

Remote villages and towns like Selawik, Alaska, are reaping the benefits from ARS's work in hybrid energy technology.

while wind power works better at pumping up deeper water. For both solar- and wind-driven systems, pumps that use impellers to lift water worked better than those with pistons.

Mixing Manure and Coal

Clark and colleagues are working with Texas A&M University on burning manure for energy. In one approach, they mix 10 percent ground-up, dried manure with 90 percent coal (by weight) and then inject it into a furnace. "This converts excess manure to energy while reducing use of nonrenewable coal," Clark says.

"We're helping a company build a boiler that uses a blend of 75 percent manure and 25 percent coal to heat water and steam for processing ethanol from corn," Clark adds. It appears to work well as long as the manure doesn't contain too much soil.

Bushland scientists are cooperating with graduate students at West Texas A&M University to examine potential uses of the mixture, such as for fertilizer or plant bedding material.

Standing in front of a wind turbine that provides half the annual electricity for the University of Minnesota-Morris, electrical engineer Steve Wagner (right) and agricultural economist Dave Archer look at a map they developed for identifying potential best-bet locations for wind turbines.

KATHY EYSTAD (D-572-1)

A Wind-Powered "Green" Campus

ARS scientists at the North Central Soil Conservation Laboratory in Morris, Minnesota, are working with the University of Minnesota at Morris on powering the campus with similarly diverse energy sources.

Says Abdullah A. Jaradat, an agronomist who leads the lab's research, "The University seeks to make itself truly a 'green' campus that uses only renewable fuels and products. It gets about 60 percent of its electricity from a wind turbine. The campus currently heats with natural gas. In the near future, cornstalks will feed a gasifier system for heating and cooling. There's a backup generator running on regular diesel, but scientists are planning to switch to either biodiesel or hydrogen fuel that produces electricity directly."

ARS electrical engineer Steve Wagner thinks that biodiesel could one day be made from *Cuphea,* a crop that does particularly well in the Northern Plains. Its unique oil could be used as a fuel source without the chemical modification required of soybean oil.

Dave Archer, an ARS economist at Morris, is studying the economic impact of biofuels on farms and rural communities. "We want to see whether they bring new jobs by creating new industries, and we want to know the effects on agricultural production and rural landscapes," he says. "We also want to encourage community wind farms jointly owned by farmers."

Mapping Best Bets

Wagner and colleagues have created maps that highlight areas of strong winds suitable for wind power generation. They used GIS (Geographic Information Systems) technology to overlay a topographical map with roads, power lines, and land ownership for a few counties in western Minnesota. They noted power lines because wind farms must have access to a heavy-duty power line within 5 to 10 miles of their connection to a power grid.

"The maps showed that we have more wind power than we knew," says Wagner. The Morris campus hopes to eventually transmit enough excess electricity to the main campus in the Twin Cities area to meet 20 percent of the university's electricity needs.

"That is," says Wagner, "until technology is developed to turn wind power into shippable hydrogen fuel that potentially could be used in fuel cells for transportation, to generate electricity, and to heat homes."

More Benefits From Biobased Energy

The University of Minnesota plans to use biomass such as cornstalks, wood, or other plant materials for energy. ARS soil scientist Jane Johnson at Morris is analyzing the resulting ash to check for heavy metals or other toxins that might render it unfit for use as fertilizer.

"Ag-based energy systems have the potential to help farm communities in many ways, providing renewable energy, an additional cash crop, and possibly new jobs," Johnson says. She is conducting experiments to determine how much residue must stay on the field to prevent soil erosion and loss of soil carbon. A certain percentage may be removed from a field—depending on crop, soil type, and other factors—without harming the soil. In fact, it can help farmers in areas like Minnesota and northern Iowa, where soils can be too wet and cold in the spring to plant. Farmers tend to avoid no-till in those areas, despite its erosion-reducing potential, because the crop residue can hold in moisture and coolness, delaying planting.

Taking the right amount of residue off for energy generation could reduce this effect and help the spread of no-till, giving farmers yet one more benefit from using their farms to produce energy.—By **Don Comis,** ARS.

This research is part of Bioenergy and Energy Alternatives, an ARS National Program (#307) described on the World Wide Web at www.nps.ars.usda.gov.

R. Nolan Clark is with the USDA-ARS Conservation and Production Research Laboratory, P.O. Drawer 10, Bushland, TX 79012-0010; phone (806) 356-5734, fax (806) 356-5750, e-mail rnclark@cprl.ars.usda.gov.

Abdullah A. Jaradat is with the USDA-ARS North Central Soil Conservation Laboratory, 803 Iowa Ave., Morris, MN 56267; phone (320) 589-3411, fax (320) 589-3787, e-mail jaradat@morris.ars.usda.gov. ✷


KATHY EYSTAD (D571-1)

The corn stover being evaluated by soil scientist Jane Johnson is a potential feedstock for gasification and cellulosic ethanol production.

STEPHEN AUSMUS (D568-1)

Agricultural engineer Brian Vick measures electrical current output from solar panels used for remote water pumping. The water is mainly used for livestock watering.