

solar wind alternative fuels

ARKANSAS
Department of Economic Development
Energy Office



consumer's guide to renewable energy in Arkansas

April 2008

CONSUMER'S GUIDE TO RENEWABLE ENERGY IN ARKANSAS

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Parts of this Consumer's Guide are based on *Get Your Power from the Sun* (DOE/GO-102003-1844); *Small Wind Electric Systems: A U.S. Consumer's Guide* (DOE/GO-102005-2095); and *Biofuels for Your State* (DOE/GO-02001-1434), all produced by the National Renewable Energy Laboratory (NREL), a DOE national laboratory.

Introduction

Renewable energy, such as solar and wind, can play a key role in creating a clean, reliable energy future in Arkansas. The benefits are many and varied, including a cleaner environment. Electricity is often produced by burning fossil fuels such as coal, oil, and natural gas. The combustion of these fuels releases a variety of pollutants into the atmosphere, such as carbon dioxide (CO₂), sulfur dioxide (SO₂), and nitrogen oxides (NO_x), which contribute to climate change, acid rain, and smog, respectively.

Renewable energy, on the other hand, is a clean energy resource. Using renewables in place of conventional fossil fuels can prevent the release of pollutants into the atmosphere and help combat global warming. For example, using solar energy to supply a million homes with energy would reduce CO₂ emissions by 4.3 million tons per year, the equivalent of removing 850,000 cars from the road.

Equally important, renewable energy technologies can improve local economies by creating jobs and keeping energy dollars in Arkansas.

Creating a renewable energy market presents important economic opportunities to Arkansas, including job creation, increased business for vendors, and strengthened local economies.

Photos: NREL/PIX 03500 and 02466.



This guide will introduce you to solar, wind, and renewable fuel technologies. Note that it is not a technical guide for designing or installing renewable energy systems. For that information, consult a professional who will have detailed technical specifications and other necessary information.

Solar Energy

Are you thinking about buying a solar electric or solar water-heating system for your home or business? If so, this section will provide basic information that can help you.

Throughout Arkansas, people are showing increased interest in capturing the sun's energy for their homes and businesses. These systems allow you to produce your own electricity and heat water with no noise and no air pollution while using a clean, renewable resource—the sun.

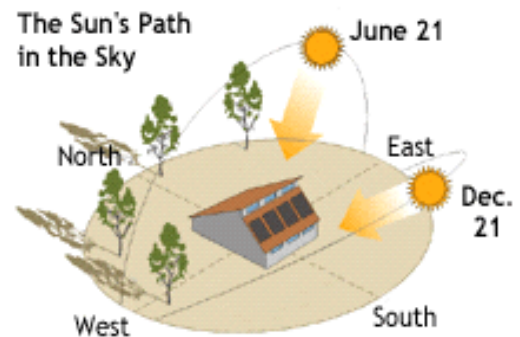
Is my site suitable for solar energy?

A well-designed solar energy system needs clear and unobstructed access to the sun's rays for most or all of the day, throughout the year. You can make an initial assessment yourself. If the location looks promising, your solar installer or equipment dealer can determine whether your home or business can effectively use a solar energy system.

The orientation of your system (the compass direction that your system faces) will affect its performance. To make the best use of your solar energy system, the modules must have a clear "view" of the sun for most or all of the day—

unobstructed by trees, roof gables, chimneys, buildings, and other features of your home and the surrounding landscape. Some potential sites for your system may be bright and sunny during certain times of the day, but shaded during other times. Such shading may substantially reduce the amount of energy that your system will produce.

In the United States, the sun is always in the southern half of the sky but is higher in the summer and lower in the winter. Usually, the best location for a



In general, the sun should be unobstructed from 9 a.m. to 3 p.m. for solar collectors. Photovoltaic applications are more sensitive to minor solar obstructions than solar thermal applications.

Photovoltaic shingles are an attractive solar option, since they look much like ordinary roofing shingles, but they also generate electricity. Photos: NREL/PIX 06288 and 12229.



solar energy system is a south-facing roof, but roofs that face east or west may also be acceptable. Flat roofs also work well for solar electric systems, because solar modules can be mounted flat on the roof facing the sky or bolted on frames tilted toward the south at an optimal angle. They can also be attached directly to the roof as "PV shingles."

If a rooftop can't be used, your solar modules can also be placed on the ground, either on a fixed mount or a "tracking" mount that follows the sun to orient the modules. Other options (often used in multifamily or commercial applications) include mounting structures that create covered parking or that provide shade as window awnings.

Photovoltaics

What is a solar electric, or photovoltaic, system?

Photovoltaic (PV) systems convert sunlight directly into electricity. They work any time the sun is shining, but more electricity is produced when the sunlight is more intense and strikes the PV modules directly (as when rays of sunlight

are perpendicular to the PV modules).

Unlike solar thermal systems for heating water, PV systems do not use the sun's heat to make electricity.

Instead, electrons freed by the interaction of sunlight with semiconductor materials in PV cells are captured in an electric current.

PV systems allow you to produce electricity—without noise or air pollution—from a clean, renewable resource.

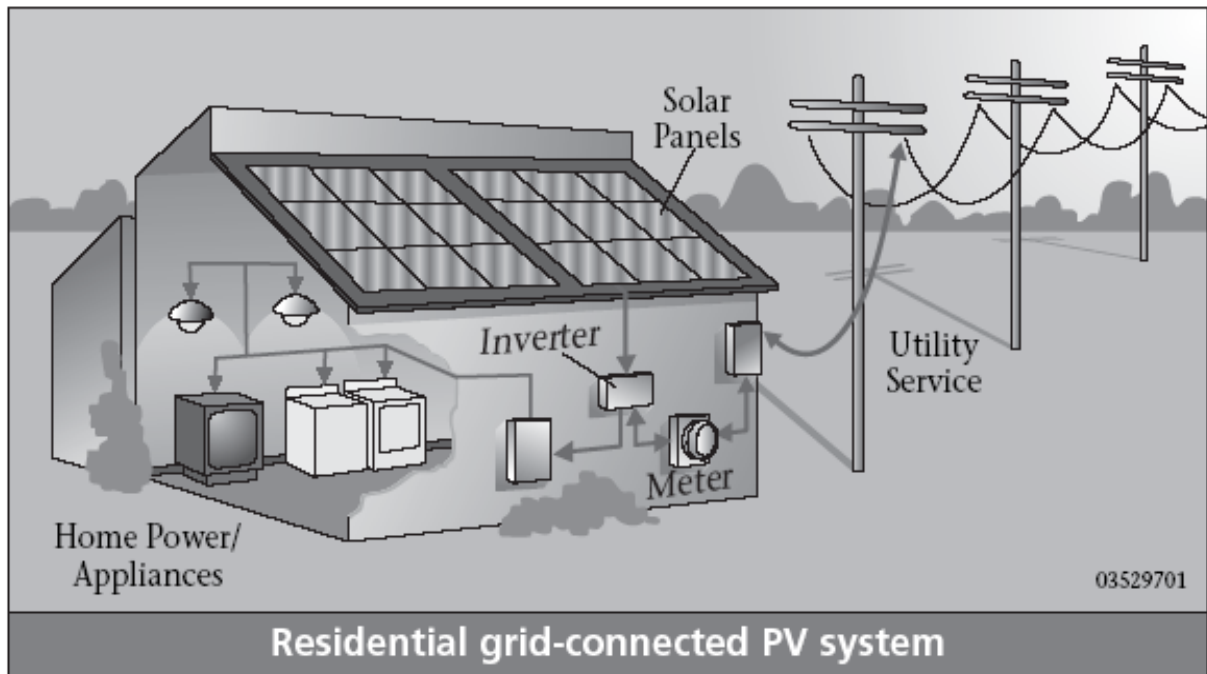
A PV system never runs out of fuel, and it won't increase U.S. oil imports. Many PV system components are manufactured right here in the United States. These characteristics could make PV technology the United States' preferred energy source for the 21st century.

*Gift shop at the Heifer Ranch in Perryville, Arkansas.
Photo: NREL/PIX 09432.*



The basic building block of PV technology is the solar "cell." Multiple PV cells are connected to form a PV "module," the smallest PV component sold commercially. Modules range in power output from about 10 watts to 300 watts. A PV system connected or "tied" to the utility grid has these components:

- One or more PV modules, which are connected to an inverter;
- An inverter, which converts the system's direct-current (DC) electricity to alternating current (AC; electricity that is compatible with the utility grid and powers our lights, appliances, computers, and televisions); and
- Batteries (optional) to provide energy storage or backup power in case of a power interruption or outage on the grid.



Cost-effectiveness will depend on system installation cost, system performance, and local electric rates.

What are the costs and savings associated with a PV system?

A PV system can be a substantial investment. As with any investment, careful planning will help you make the right decisions for your home or business. Before you decide to buy a PV system, you should consider the following things. First, PV systems produce power intermittently because they only work when the sun is shining. This is not a problem for PV systems connected to the utility grid, because any additional electricity required is automatically delivered to you by your utility. In the case of non-grid, or stand-alone, PV systems, batteries can be purchased to store energy for later use. Second, if you live near existing power lines, PV-generated electricity is usually more expensive

than conventional utility-supplied electricity. Although PV now costs less than 1 percent of what it did in the 1970s, the amortized price over the life of the system is still about 25 cents per kilowatt-hour. This is double to quadruple what most people pay for electricity from their utilities. A solar rebate program and net metering can help make PV more affordable, but they can't match today's price for utility-supplied electricity in most cases. Finally, unlike the electricity you purchase monthly from a utility, PV power requires a high initial investment. This means that buying a PV system is like paying years of electric bills up front. Your monthly electric bills will go down, but the *initial* expense of PV may be significant. By financing your PV system, you can spread the cost over many years, and rebates can also lighten your financial load.

The value of your PV system's electricity depends on how much you pay for electricity now and how much your utility will credit you for any excess power that you generate. With net

metering (see page 11), the PV system's electricity is metered back to the utility, which offsets the electricity coming from the utility. You can use the calculation box above to estimate how much electricity your PV system will produce and how much that electricity will be worth. Actual

energy production from your PV system will vary by up to 20 percent from these figures, depending on your geographic location, the angle and orientation of your system, the quality of the components, and the quality of the installation. Be sure to discuss these issues with your PV provider. Request a written estimate of the average annual energy production from the PV system. However, even if an estimate is accurate for an average year, actual electricity production will fluctuate from year to year because of natural variations in weather and climate.

How much does a PV system cost?

No single answer applies in every case, but solar rebates and other incentives will always reduce the cost. Your price depends on a number of factors, including whether your home is under construction and whether PV is integrated into the roof or mounted on top of an existing roof. The price also depends on the PV system's rating, the manufacturer, the retailer, and the installer. The size of your system may be the most significant factor in any measurement of costs versus benefits. A 2-kilowatt system that meets nearly all the needs of a very energy-efficient home will likely cost \$8 to \$10 per watt, or \$16,000 to \$20,000 installed. At the high end, a 5-kilowatt system that completely meets the energy needs of a large conventional home can cost \$30,000 to \$40,000 installed, or \$6 to \$8 per watt. These prices are rough

Energy Produced by a Grid-Connected PV System*					
Location	1-kW	2-kW	3-kW	4-kW	5-kW
Fort Smith	1,331	2,662	3,993	5,324	6,655
Little Rock	1,297	2,594	3,891	5,188	6,485

* Estimated annual output in kWh/year. A typical home uses an average of 9,400 kWh per year. Contact your utility to request a printout of your last 12 months of electrical energy consumption.

Area of Solar Array Needed (Square Feet)*							
PV Module Efficiency	PV Capacity Rating						
	100 watts	250 watts	500 watts	1,000 watts	2,000 watts	4,000 watts	10,000 watts
4%	30	75	150	300	600	1,200	3,000
8%	15	38	75	150	300	600	1,500
12%	10	25	50	100	200	400	1,000
16%	8	20	40	80	160	320	800

* For example, to generate 2,000 watts from a 12%-efficient system, you need 200 square feet of roof area.

The table above shows approximate area requirements in square feet.

estimates; your costs depend on your system's configuration, your equipment options, and other factors. Your local PV dealers can give you more accurate cost information.

As with all sources of renewable energy generation, the less you need (reducing consumption through efficiency and conservation) the less it will cost to generate. The first steps to consider are "How much electricity do I really need?" and "Where can I cut my unnecessary electrical consumption?"





Photovoltaics provides year round solar-assisted power to a domestic water heating system for this residential addition in Rhode Island. Photo: NREL/PIX 10553.

Solar Water Heating

Water heating can account for as much as 25 percent of a typical family's energy costs. But a properly sized solar water heating system could cut those costs in half.

Solar Water Heater Basics

Solar water heating systems use the sun to heat either water or a heat-transfer fluid, such as a water-glycol antifreeze mixture, in collectors most commonly mounted on a roof. The heated water is then stored in a tank similar to a conventional gas or electric water tank. Then, when water is drawn from the water heater, it is replaced with the solar-heated water from that tank.

Solar water heaters can operate in any climate. Performance varies depending, in part, on how much solar energy is available at the site, but also on the temperature of incoming water. The colder the water, the more efficiently the system operates. In almost all climates, you will need a conventional backup system. In fact, many building codes require you to have a conventional water heater as the backup.

Types of Solar Water Heaters

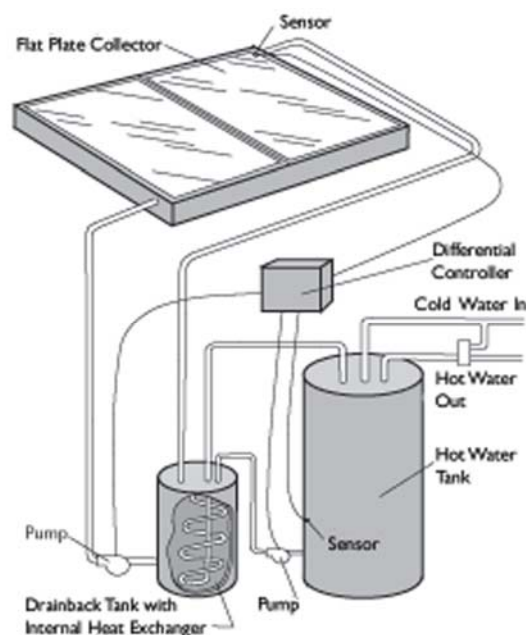
There are four basic types of solar water-heating systems available. These systems share three similarities: a glazing (typically glass) over a dark surface to gather solar heat; one or two tanks to store hot water; and associated plumbing with or without pumps to circulate the heat-transfer fluid from the tank to the collectors and back again. The four types of systems are:

Draindown systems pump water from the hot water tank through the solar collectors, where it is heated by the sun and returned to the tank. Valves automatically drain the system when sensors detect freezing temperatures.

Drainback systems use a separate plumbing line, filled with fluid, to gather the sun's heat. These systems operate strictly on gravity. When the temperature is near freezing, the pump shuts off and the transfer fluid drains back into the solar storage tank.

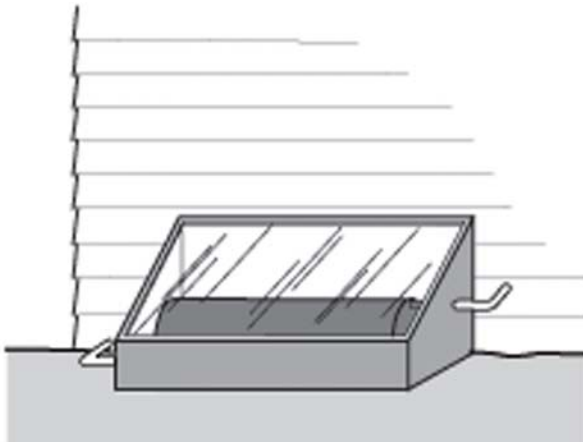


*Draindown solar water system.
Illustration: North Carolina Solar Center.*



*Drainback solar water system.
Illustration: North Carolina Solar Center.*

Antifreeze closed-loop systems rely on an antifreeze solution to operate through cold winter months. Antifreeze solutions are separated from household water by a double-walled heat exchanger.



Breadbox batch systems are passive systems in which the storage tank also functions as the collector. One or two water tanks, painted black, are placed in a well-insulated box or other enclosure that has a south wall made of clear plastic or glass and tilted at the proper angle. This allows the sun to shine directly on the tank and

heat a "batch" of water. An insulated cover can provide freeze protection.

Sizing Your System

Just as you have to choose a 30-, 40-, or 50-gallon conventional water heater, you need to determine the right size solar water heater to install. Sizing a solar water heater involves determining the total collector area and the storage volume required to provide 100 percent of your household's hot water during the summer. Solar equipment experts use worksheets or special computer programs to assist you in determining how large a system you need.

Solar storage tanks usually have 50-, 60-, 80-, or 120-gallon capacities. A small (50- to 60-gallon) system is sufficient for one to three people, a medium (80-gallon) system is adequate for a three- or four-person household, and a large (120-gallon) system is appropriate for four to six people.

A rule of thumb for sizing collectors: allow about 20 square feet (about 2 square meters) of collector area for each of the first two family members and 8 square feet (0.7 square meters) for each additional family member.

How Much Does a Solar Water Heating System Cost?

A solar water heating system can cost anywhere from \$1,500 to more than \$5,000. Cost depends on a number of variables, such as:

- the presence or type of freeze protection,
- the size of family to be served,
- the size and type of solar system,
- the type of roof on which the collector is to be installed,
- building code requirements, and
- whether installation is done by a professional or the homeowner.

A solar energy supplier or installer in your area can help you determine specific costs for your system.

Breadbox batch solar water system. Illustration: North Carolina Solar Center.

The less expensive solar water-heating systems lack freeze protection and are applicable primarily for recreational summer homes.

How Much Will I Save?

Savings from solar water heating depend on specific climate, conventional fuel costs, and other factors. However, a study by the Florida Solar Energy Center concluded that solar water heaters could reduce water heating costs by as much as 85 percent annually. Paybacks vary widely, but you can expect a simple payback of four to eight years on a well-designed and properly installed solar water heater. (Simple payback is the length of time required to recover your investment through reduced or avoided energy costs. After that time, it's money in the bank.)

If you are building a new home or refinancing your present home to do a major renovation, the economics are even more attractive. The cost of including the price of a solar water heater in a new 30-year mortgage is usually between \$13 and \$20 per month. The portion of the federal income tax deduction for mortgage interest attributable to the solar system reduces that amount by about \$3 to \$5 per month. If your fuel savings are more than \$15 per month, the investment in the solar water heater is immediately profitable.

First Things First

Before investing in any solar energy system, it is more cost-effective to invest in making your home more energy-efficient. Taking steps to use less hot water and to lower the temperature of the hot water you use reduces the size and cost of your solar water heater.

Good first steps are installing low-flow showerheads or flow restrictors in faucets, insulating your current water heater, and insulating any hot water pipes that you can see. If you have no dishwasher, or your dishwasher is equipped with its own automatic water heater, lower the thermostat on your water heater to 120°F (49°C). For more information on ways to use less energy for water heating, see the Arkansas Energy Office publication titled *Water Heaters*—one of six consumer's guides to help lower energy bills—at www.arkansasenergy.org.

You'll also want to make sure your site has enough available sunshine to meet your needs efficiently and economically. Your local solar equipment dealer can perform a solar site analysis for you or show you how to do your own (see page 2).

Remember, local zoning laws or covenants may restrict where you can place your collectors. Check with your city, county, and homeowners association to find out about any restrictions.

Be a Smart Consumer

Take the same care in choosing a solar water heater that you would in the purchase of any major appliance. Your best protection is to consider only certified and labeled systems. One such label is put on by the Solar Rating & Certification Corporation (SRCC), a nonprofit, independent third-party organization formed by the state energy officials and consumer advocates to certify and rate solar water heaters.

Find out if the manufacturer offers a warranty, and, if so, what the warranty covers and for how long. Also find out if the dealer you are buying the equipment from goes out of business, can you get support and parts from the manufacturer, or from a local plumbing contractor.

Make sure that the workers who are actually installing the system are qualified to do the work. In Arkansas, an installer of a solar water heater must have a plumbing license. Ask the installation contractor for references and check them. When the job is finished, have the contractor walk you through the system so you are familiar with the installation. Also be sure that an owner's manual with maintenance instructions is included as part of the package.

A solar water heater is a long-term investment that will save you money and energy for many years. Like other renewable energy systems, solar water heaters minimize the environmental effects of enjoying a comfortable, modern lifestyle. In addition, they provide a hedge against energy price increases, help reduce our dependence on foreign oil, and are investments in everyone's future.

Financial Incentives

State

Net Metering

In Arkansas, as in 39 other states, electric utilities are required to offer net metering. In net metering, the customer is billed for the net electricity purchased from the utility—that is, the difference between the electricity coming from the power grid and the excess electricity generated by the renewable energy system. Revisions to Arkansas' Net Metering Rule (Act 1026 of 2007) require electric utilities to credit a net-metering customer with any accumulated net excess generation at the end of each billing cycle. Then, at the end of the 12-month period, any unused excess generation credits expire. The benefits of net metering to consumers are especially significant in areas with high retail electric rates. Utilities also benefit because solar-generated energy often coincides with their periods of "peak" demand for electricity.

ARKANSAS PUBLIC SERVICE COMMISSION



NET METERING RULES

Approved by Order #4 Docket No. 02-046-R (7-26-2002)
Amended by Order #8 Docket No. 06-105-U (11-27-2007)
Amended by Order #10 Docket No. 08-105-U (11-29-2007)
Amended by Order #11 Docket No. 08-105-U (11-30-2007)
Amended by Order #12 Docket No. 08-105-U (12-19-2007)

Crews are installing solar thermal collectors and PV panels on the roof to provide hot water and electricity for this new Habitat for Humanity home.
Photo: NREL/PIX 14162.

In Arkansas, residential renewable energy systems rated with a generating capacity of up to 25 kW and non-residential systems up to 300 kW are eligible for net metering. Eligible technologies include solar, wind, hydroelectric, geothermal, and biomass systems, as well as fuel cells and microturbines that use renewable fuels. There is no limit on the number of customers per utility who may net meter.

The revised rules became effective on January 1, 2008. The Arkansas net metering rules are at the Arkansas Public Service Commission's web site at http://170.94.29.3/rules/net_metering_rules.pdf.

Federal

Residential Solar and Fuel Cell Tax Credit

Extended by the Tax Relief and Health Care Act of 2006, this credit applies to solar water heaters, solar electric systems, and fuel cells. The incentive amount is 30 percent, with maximums of \$2,000 for solar electric systems and solar water heaters and \$500 per 0.5 kW for fuel cells. The tax credit is expected to expire on December 31, 2008. For more information on the Tax Relief and Health Care Act of 2006 and what it means to you, visit DOE's



Office of Energy Efficiency and Renewable Energy at www.eere.energy.gov/news/news_detail.cfm/news_id=10489.

Business Energy Tax Credit

Extended by the Tax Relief and Health Care Act of 2006, this credit applies to the following renewable technologies when used for commercial or industrial applications: solar water heating, solar space heating, solar thermal electric, solar thermal process heat, photovoltaics, geothermal electric, fuel cells, and solar hybrid lighting. The tax credit is for 30 percent of expenditures on solar technologies installed from January 1, 2006 through December 31, 2008. Starting on January 1, 2009 the tax credit for solar technologies drops down to ten percent of expenditures. For more information on the Tax Relief and Health Care Act of 2006 and what it means to you, visit DOE's Office of Energy Efficiency and Renewable Energy at www.eere.energy.gov/news/news_detail.cfm/news_id=10489.

USDA Renewable Energy Systems and Energy Efficiency Improvements Program

This federal grant program applies to the following renewable technologies when used for agriculture and small rural businesses: solar water heating, solar space heating, photovoltaics, wind, biomass, geothermal electric, geothermal heat pumps, hydrogen, anaerobic digestion, renewable fuels, and fuel cells. Grants amount to 25 percent of eligible project costs; guaranteed loans are 50 percent of eligible project costs. Maximums are \$500,000 per renewable-energy project for grants, and \$10 million for guaranteed loans. There are currently two deadlines for applying: grant applications by April 15, 2008 and then either grant or guaranteed loan applications by June 16, 2008. For more information on this program, go to www.rurdev.usda.gov/rbs/farbill/.

Note that state and federal incentives change regularly. For additional, up-to-date information, see the Database of State Incentives for Renewable Energy (DSIRE) at www.dsireusa.org/.

Wind Energy

More and more people are considering wind energy as they look for affordable and reliable sources of electricity. Small wind electric systems can make a significant contribution to our nation's energy needs. Although wind turbines large enough to provide a significant portion of the electricity needed by the average U.S. home generally require one acre of property or more, approximately 21 million U.S. homes are built on one-acre and larger sites, and 24 percent of the U.S. population lives in rural areas. Many of these rural areas, particularly in the western U.S., also have sufficient wind speeds to make wind an attractive alternative. Conversely, Arkansas generally has more modest potential with viable wind resources in certain site-specific locations. This section will provide you with the basic information about small wind electric systems to help you decide if wind energy will work for you.



Homeowners, ranchers, and small business owners can use wind-generated electricity to reduce their utility bills. This grid-connected system installed for a home in Norman, Oklahoma, reduces the homeowner's utility bill by \$100 per month. Photo: NREL/PIX 01476.

Why Should I Choose Wind?

Under certain circumstances, wind energy systems can be a cost-effective home-based renewable energy system. Depending on your wind resource, a small wind energy system can lower your electricity bill, help you avoid the high costs of having utility power lines extended to remote locations, and prevent power interruptions.

How Do Wind Turbines Work?

Wind is created by the unequal heating of the Earth's surface by the sun. Wind turbines convert the kinetic energy in wind into mechanical power that runs a generator to produce clean electricity. Today's turbines are versatile modular sources of electricity. Their blades are aerodynamically designed to capture the maximum energy from the wind. The wind turns the blades, which spin a shaft connected to a generator that makes electricity.

Is Wind Energy Practical for Me?

A small wind energy system can provide you with a practical and economical source of electricity if:

- your property has a good wind resource;

- your home or business is located on at least one acre of land in a rural area;
- your local zoning codes or covenants allow wind turbines;
- your average electricity bills are \$150 per month or more;
- your property is in a remote location that does not have easy access to utility lines; and
- you are comfortable with long-term investments.



Wind turbines operate in harmony with farming and ranching.

Photo: NREL/PIXI 4070.

Is There Enough Wind at My Site?

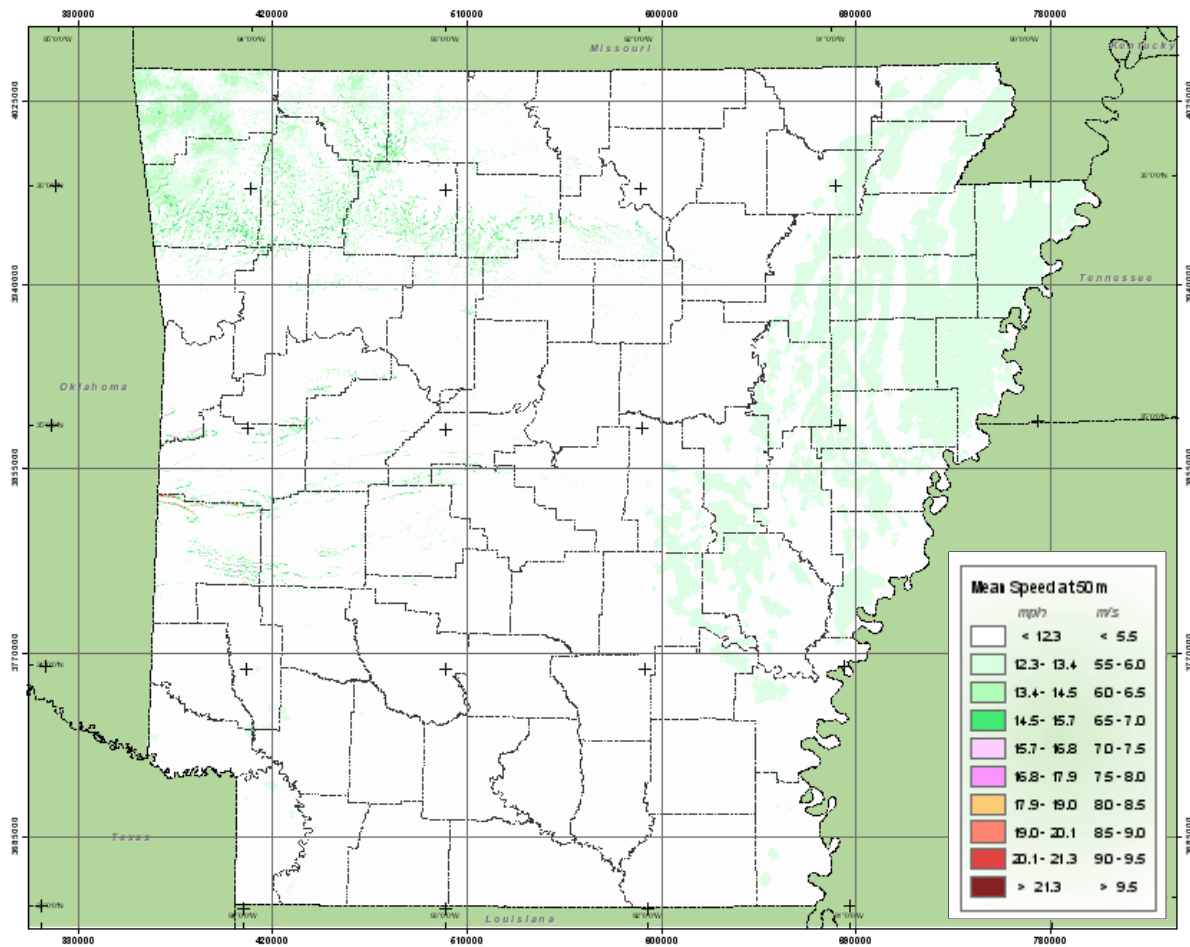
Does the wind blow hard and consistently enough at my site to make a small wind turbine system economically worthwhile? This is a key question that is not always easily answered. The wind resource can vary significantly over an area of just a few miles because of local terrain influences on wind flow. Yet, there are steps you can take that will go a long way towards answering the above question.

As a first step, wind resource maps like the one shown on the next page can be used to estimate the wind resource in your region. Local terrain features may cause the wind resource at a specific site to differ considerably from those shown in maps of this nature. This Arkansas wind speed map at 50 meters, as well as other maps of estimated wind speed and power for Arkansas, can be found at <http://www.awstruewind.com/maps/united-states.cfm/region/46635>.

Another way to indirectly quantify the wind resource is to obtain average wind speed information from a nearby airport. However, caution should be used because local terrain influences and other factors may cause the wind speed recorded at an airport to be different from your particular location. Airport wind data are generally measured at heights about 20-33 feet (6–10 meters) above ground.

Average wind speeds increase with height and may be 15–25 percent greater at a typical small wind turbine hub-height of 80 feet (24 meters) than those measured at airport anemometer heights. The National Climatic Data Center collects data from airports in the U.S. and makes wind data summaries available for purchase. Summaries of wind data from almost 1,000 U.S. airports also are included in the *Wind Energy Resource Atlas of the United States*, available online at <http://rredc.nrel.gov/wind/pubs/atlas/>.

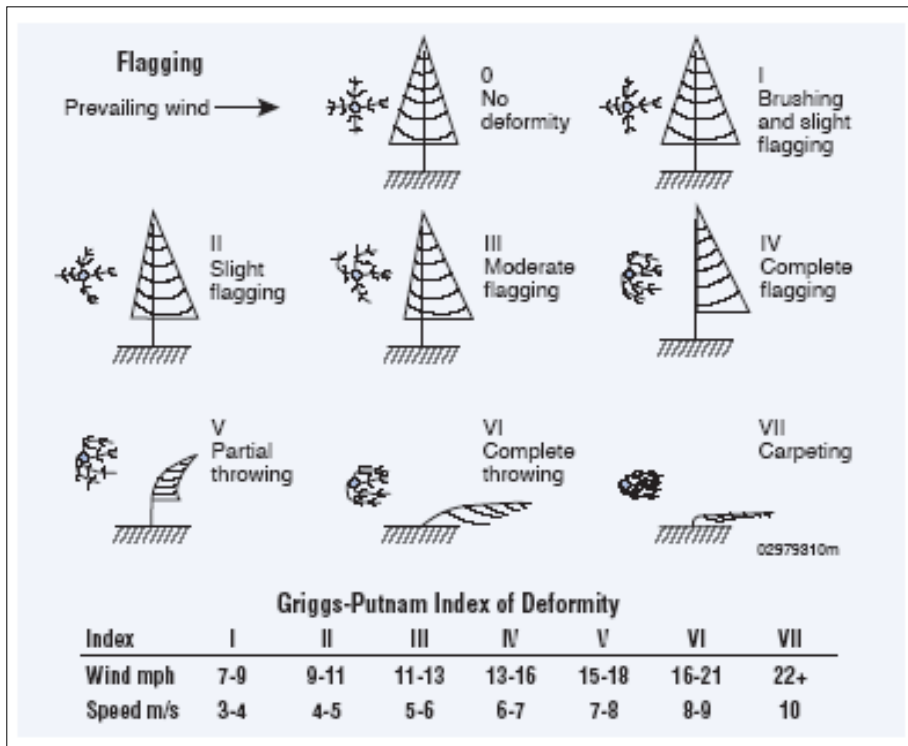
While Arkansas' wind resources are generally not ideal, there are a few areas in the northwest corner of the state where wind energy is economically viable.



Arkansas annual mean wind speed at 50 meters.
Source: AWS Truewind.

Another useful indirect measurement of the wind resource is the observation of an area's vegetation. Trees, especially conifers and evergreens, can be permanently deformed by strong winds. This deformity, known as "flagging," has been used to estimate the average wind speed for an area. For more information on flagging, you may want to obtain *A Siting Handbook for Small Wind Energy Conversion Systems*, by H. Wegley, J. Ramsdell, M. Orgill, and R. Drake, Report No. PNL-2521, available from the National Technical Information Service at www.ntis.gov or (703) 605-6585.

Direct monitoring by a wind resource measurement system at a site provides the clearest picture of the available resource. A good overall guide on this subject is the *Wind Resource Assessment Handbook*, which is available online at www.nrel.gov/wind/pdfs/22223.pdf. Available wind measurement systems cost as little as \$600 to \$1,200. This expense may or may not be hard to justify depending on the exact nature of the proposed small wind turbine system. The measurement equipment must be set high enough to avoid turbulence created by trees, buildings, and



Flagging, the effect of strong winds on area vegetation, can help determine area wind speeds.

other obstructions. The most useful readings are those taken at hub-height, the elevation at the top of the tower where the wind turbine is going to be installed. If there is a small wind turbine system in your area, you may be able to obtain information on the annual output of the system and also wind speed data.

Zoning Issues

Before you invest in a wind energy system, you should research potential obstacles. Some jurisdictions, for example, restrict the height of the structures permitted in residentially zoned areas, although variances are often obtainable. Most zoning ordinances have a height limit of 35 feet. You can find out about the zoning restrictions in your area by calling the local building inspector, board of supervisors, or planning board. They can tell you if you will need to obtain a building permit and provide you with a list of requirements. In addition to zoning issues, your neighbors might object to a wind system that blocks their view, or they might be concerned about noise. Most zoning and aesthetic concerns can be addressed by supplying objective data. For example, the ambient noise level of most modern residential wind turbines is around 52 to 55 decibels. This means that while the sound of the wind turbine can be picked out of surrounding noise if a conscious effort is made to hear it, a residential sized wind turbine is no noisier than your average refrigerator.

What Size Wind Turbine Do I Need?

The size of the wind turbine you need depends on your application. Small turbines range in size from 100 watts to 100 kilowatts. The smaller or "micro" (100– to 500-watt) turbines are used in a variety of applications such as charging batteries for recreational vehicles and sailboats. One- to 10-kW turbines can be used in applications such as pumping water. Wind energy has been used for centuries to pump water and grind grain. Although mechanical windmills still provide a sensible, low-cost option for pumping water in low-wind areas, farmers and ranchers are finding that wind-electric pumping is a little more versatile and they can pump twice the volume for the same initial investment. In addition, mechanical windmills must be placed directly above the well, which may not take the best advantage of available wind resources. Wind-electric pumping systems can be placed where the wind resource is the best and connected to the pump motor with an electric cable.

Turbines used in residential applications can range in size from 400 watts to 100 kW (100 kW for very large loads), depending on the amount of electricity you want to generate. For residential applications, you should establish an energy budget to help define the size of the turbine you will need. Because energy efficiency is usually less expensive than energy production, making your house more energy-efficient first will probably be more cost-effective and will reduce the size of the wind turbine you need. Wind turbine manufacturers can help you size your system based on your electricity needs and the specifics of local wind patterns.

A typical home uses approximately 9,400 kilowatt-hours (kWh) of electricity per year (about 780 kWh per month). Depending on the average wind speed in the area, a wind turbine rated in the range of 5 to 10 kilowatts (kW) would be required to make a significant contribution to this energy need. The manufacturer can provide you with the expected annual energy output of the turbine as a function of annual average wind speed. The manufacturer will also provide information on the maximum wind speed at which the turbine is designed to operate safely. Most turbines have automatic overspeed-governing systems to keep the rotor from spinning out of control in very high winds. This information, along with your local wind speed and your energy budget, will help you decide which size turbine will best meet your electricity needs.

Grid-Connected Systems

In grid-connected systems, the only additional equipment required is a power conditioning unit (inverter) that makes the turbine output electrically compatible with the utility grid. Usually, batteries are not needed. Small wind energy systems can be connected to the electricity distribution system and are called grid-connected systems. A grid-connected wind turbine can reduce

Wind Turbine Sizes*		
Size	Height	Diameter
1 kW	30 - 100 ft	4 - 8 ft
10 kW	60 - 120 ft	23 - 25 ft
100 kW	80 - 120 ft	56 - 60 ft

* These are examples; specific component sizes vary by manufacturer.

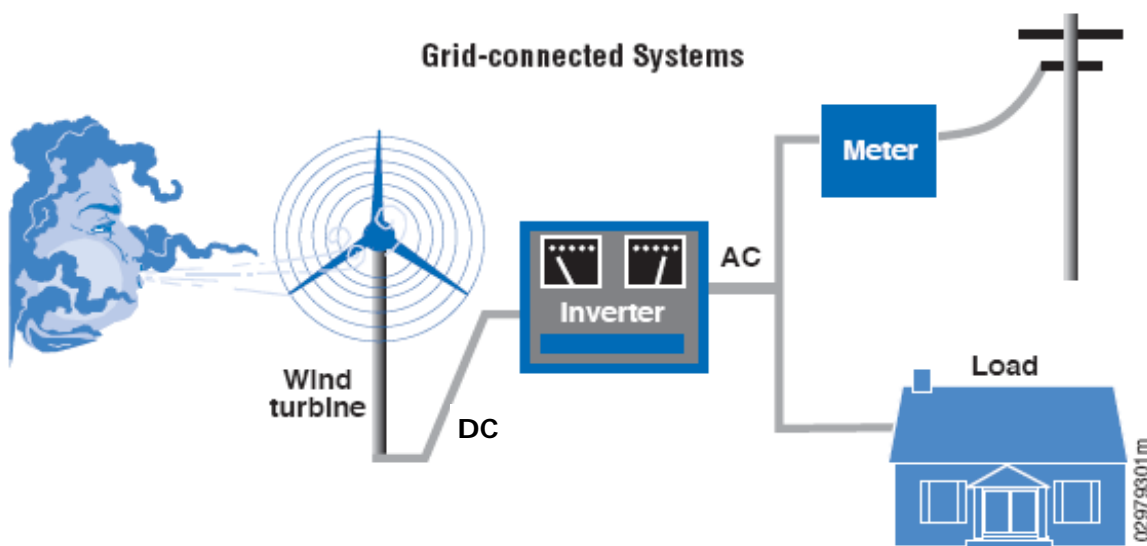
This table shows common tower height and diameter of blades for several wind turbine sizes. A general rule of thumb is that the higher wind turbines are placed, the more energy they will produce.

your consumption of utility-supplied electricity for lighting, appliances, and electric heat. If the turbine cannot deliver the amount of energy you need, the utility makes up the difference. When the wind system produces more electricity than the household requires, the excess enters the grid. Grid-connected systems can be practical if the following conditions exist:

- you live in an area with average annual wind speed of at least 10 mph (4.5 m/s);
- utility-supplied electricity is expensive in your area (about 10 to 15 cents per kilowatt-hour);
- the utility's requirements for connecting your system to its grid are not prohibitively expensive; and
- there are good incentives for the sale of excess electricity or for the purchase of wind turbines.

Depending on the type of system, state and federal regulations (specifically, Arkansas' Net Metering Rule and the Public Utility Regulatory Policies Act of 1978, or PURPA) require utilities to connect with small wind energy systems. However, you should contact your utility before connecting to their distribution

A grid-connected wind turbine can reduce your consumption of utility-supplied electricity.



lines to address any power quality and safety concerns. Your utility can provide you with a list of requirements for connecting your system to the grid. The American Wind Energy Association (www.awea.org) is another good source for information on utility interconnection requirements.

What Do Wind Systems Cost?

A small turbine can cost anywhere from \$3,000 to \$35,000 installed, depending on size, application, and service agreements with the manufacturer. A general rule of thumb for estimating the cost of a residential turbine is \$3,000 per kilowatt for a 10-kW system. Smaller wind systems are more costly per kilowatt of installed capacity. Wind energy becomes more cost-effective as the size of the turbine's rotor increases. Although small turbines cost less in initial outlay, they are proportionally more expensive. The cost of an installed residential wind energy system that comes with an 80-foot tower, batteries, and inverter, typically ranges from \$13,000 to \$40,000 for a 3- to 10-kW wind turbine. Although wind energy systems involve a significant initial investment, they can be competitive with conventional energy sources when you account for a lifetime of reduced or avoided utility costs. The length of the payback period—the time before the savings resulting from your system equal the cost of the system itself—depends on the system you choose, the wind resource on your site, electricity costs in your area, and how you use your wind system.

Financial Incentives



State **Net Metering**

In Arkansas, as in more than 39 other states, electric utilities are required to offer net metering. In net metering, the customer is billed for the net electricity purchased from the utility—that is, the difference between the electricity coming from the power grid and the excess electricity generated by the renewable energy system. Revisions to Arkansas' Net Metering Rule (Act 1026 of 2007) require electric utilities to credit a net-metering customer with any accumulated net excess generation at the end of each billing cycle. Then, at the end of the 12-month period, any unused excess generation credits expire. The benefits of net metering to consumers are especially significant in areas with high retail electric rates. Utilities also benefit because solar-generated energy often coincides with their periods of "peak" demand for electricity.

In Arkansas, residential renewable energy systems rated with a generating capacity of up to 25 kW and non-residential systems up to 300 kW are eligible for net metering. Eligible technologies include solar, wind, hydroelectric, geothermal, and biomass systems, as well as fuel cells and microturbines that use renewable fuels. There is no limit on the number of customers per utility who may net meter.

The revised rules became effective on January 1, 2008. The Arkansas net metering rules are at the Arkansas Public Service Commission's web site at http://170.94.29.3/rules/net_metering_rules.pdf.

Federal

USDA Renewable Energy Systems and Energy Efficiency Improvements Program

This federal grant program applies to the following renewable technologies when used for agriculture and small rural businesses: solar water heating, solar space heating, photovoltaics, wind, biomass, geothermal electric, geothermal heat pumps, hydrogen, anaerobic digestion, renewable fuels, and fuel cells. Grants amount to 25 percent of eligible project costs; guaranteed loans are 50 percent of eligible project costs. Maximums are \$500,000 per renewable-energy project for grants, and \$10 million for guaranteed loans. There are currently two deadlines for applying: grant applications by April 15, 2008 and then either grant or guaranteed loan applications by June 16, 2008. For more information on this program, go to www.rurdev.usda.gov/rbs/farbill/.

Wind Energy Production Tax Credit

The Tax Relief and Health Care Act of 2006 extends the corporate tax credit for wind energy systems. The tax credit amounts to 1.9 cents-per-kilowatt-hour tax credit for electricity generated with wind turbines over the first ten years of a project's operations. This tax credit is subject to funding limitations and is set to expire December 31, 2008.

Note that state and federal incentives change regularly. For additional, up-to-date information, see the Database of State Incentives for Renewable Energy (DSIRE) at www.dsireusa.org/.

Renewable Fuels for Transportation

Transportation accounts for 65 percent of U.S. oil consumption and is the predominant source of air pollution. However, there are safe, environmentally friendly alternative fuels that can act as substitutes for gasoline and diesel or be blended with them to reduce toxic air emissions. Using renewable fuels also reduces greenhouse gas buildup, dependence on imported oil, and trade deficits, while supporting local agriculture and rural economies.

What are renewable fuels?

Renewable fuels are not petroleum-based, so they're cleaner burning. Some examples of renewable fuels include:

- **Biodiesel** – a low-polluting diesel alternative fuel made from vegetable oils, animal fats, and even recycled cooking greases.
- **Ethanol** – an alcohol-based fuel derived from crops such as corn, barley, and wheat. Ethanol can be blended with gasoline in varying concentrations. E85, for example, is a blend of 85 percent ethanol and 15 percent gasoline.

The Energy Policy Act of 1992 (EPAct) requires state and federal government fleets to purchase renewable fuel vehicles for three-quarters of their new light-duty vehicle purchases. Additionally, alternative fuel provider fleets covered by EPAct are required to purchase renewable fuel vehicles for 90 percent of their new vehicle purchases. Local government and private fleets are not covered by this rule, but the U.S. Department of Energy has the authority to include them at a future date. Typically, the standard ethanol fuel is E85, a blend of 85 percent ethanol and 15 percent gasoline. Flexible-fuel vehicles designed to use E85 or other gasoline mixtures include modified oxygen sensors and different seals in the fuel system. Because ethanol has less energy per gallon than gasoline, E85 vehicles also need larger fuel tanks to keep the same range. E85 flex-fuel vehicles qualify as alternative fuel vehicles and Daimler-Chrysler, Ford, and General Motors all offer several models designed to use E85 or gasoline for the same price as gasoline-only

Increasing the use of environmentally friendly fuels and vehicles can result in a cleaner environment and stronger local economies.



models. Today, 92 state and alternative fuel provider fleets use E85 flex-fuel vehicles to help them meet their EPEAT requirements.

Alternative Fuel Vehicles

Alternative fuel vehicles (AFVs) use renewable fuel instead of gasoline or diesel fuel. AFVs range in size and shape, from small commuter cars to large 18-wheeler trucks. A number of automobile manufacturers offer light-duty vehicles for personal transportation.

AFVs are well-suited for fleets in certain "niche" markets. Taxi fleets, for example, are high-mileage vehicles that drive fairly centralized routes and may benefit from using a less expensive alternative fuel such as natural gas or propane. Local delivery fleets with low mileage, and high-use vehicles that frequently idle in traffic or must often start and stop, may be good candidates for electric vehicles. Medium- and heavy-duty AFV applications include transit buses, airport shuttles, delivery trucks and vans, school buses, refuse haulers, and street sweepers.



Alternative fuel vehicles are well-suited for security and police fleets, transit and delivery, agency fleets, and more.

Photo: NREL/PIX 09768.

AFV Types

- **Flex-Fuel Vehicles** can be fueled with gasoline or, depending on the vehicle, with either methanol (M85) or ethanol (E85). The vehicles have one tank and can accept mixtures of gasoline and the alternative fuel.
- **Bifuel or Dual-Fuel Vehicles** have two tanks—one for gasoline and one for either natural gas or propane, depending on the vehicle. The vehicles can switch between the two fuels.
- **Dedicated Vehicles** are designed to be fueled only with an alternative fuel. Electric vehicles are a special type of dedicated vehicle.
- **Hybrid Vehicles** combine the best features of two different energy sources by switching between an electric motor and a fuel-powered engine.



Fueling

Alternative fuel stations are becoming increasingly popular across the country, as more consumers and agencies turn to cleaner fuels. As depicted in the map below, there are currently 27 counties in Arkansas that have at least one fueling station with an alternative fuel. To find the alternative fuel fueling station nearest you use the Arkansas Farm Bureau's station locator at http://www.arfb.com/commodity_marketing/biodiesel/default.aspx.

Ethanol

At the end of 2007, there were over 134 ethanol plants operating in the U.S., which produced over 7,000 million gallons of ethanol .

From Corn

In the U.S., ethanol, also known as grain alcohol, is made from the starch in kernels of corn. In 2006, 14 percent of the U.S. corn crop went towards ethanol production, and that number is expected to grow to 30 percent by 2010. Modern fuel ethanol technology is sophisticated, and the process is similar to making alcoholic beverages. Starch is converted into sugars, the sugars are fermented into a "beer," and then the beer is distilled to make pure ethanol. There are two types of U.S. corn ethanol production plants,

Counties in Arkansas with biofuel fueling stations. Image: Arkansas Farm Bureau.





those that use wet-milling versus dry-milling. Wet-mill plants are typically large operations that produce ethanol along with a slate of food products such as corn sweeteners, corn syrup, corn oil, and gluten feed. Dry-mill plants are typically smaller facilities that produce ethanol as their primary product and a high-protein animal

feed known as distillers dried grains as a co-product. The dry-mill plants are typically located in rural communities and are often farmer-owned, which make them an excellent way to develop their local economies.

Ethanol made from corn is slightly more expensive than gasoline. To encourage ethanol use, however, the federal government exempts 5.3 cents per gallon of 10 percent ethanol blend (53 cents per gallon of ethanol) of the 18.3 cents per gallon federal fuel excise tax. In effect since 1979, this exemption makes ethanol competitive for fuel additive use. Several states also provide additional incentives. The federal subsidy, however, is more than offset by reduced agricultural price support payments, and increased employment taxes for an estimated net taxpayer savings of about \$3.6 billion per year.

From Other Starch or Sugar

Even states with a small corn crop can benefit from building ethanol plants. Conventional ethanol technology can process any starch or sugar source. While corn certainly predominates, U.S. plants are currently making ethanol from barley, wheat starch, potato waste, cheese whey, and brewery and beverage waste.

From Cellulose and Hemicellulose

Starches and sugars constitute only a small portion of plant matter. The bulk of most plants consists of cellulose, hemicellulose, and lignin. Cellulose and hemicellulose, though, are made of chains of sugars. Advanced bioethanol technology can break these chains down into their component sugars, which can then be fermented into ethanol. This makes it possible to produce ethanol from virtually any biomass material. In the near-term, ethanol will probably be made from low- or "negative-cost opportunity" feedstocks such as municipal waste, wood processing waste, sugarcane

Corn is a common feedstock for ethanol, providing an economic boon for many agricultural states. Photo: NREL/PIX 00082

bagasse, rice hulls, or rice straw. In the mid-term, ethanol sources will include agricultural and forestry residues such as corn stover—a huge potential source—or wood chips.

Arkansas has excellent biomass resource potential: the estimated supplies of urban and mill residues available for energy uses in Arkansas are 667,000 and 4,705,000 dry tons per year, respectively. An estimated 984,000 dry tons per year is available from corn stover and wheat straw in Arkansas.

In the long-term, farmers may grow dedicated energy crops, such as switchgrass or fast-growing trees, just for fuel production. Because it requires sophisticated conversion technology, making ethanol from cellulosic biomass is currently more expensive than making it from corn grain—especially when using waste or residue feedstocks. However, cellulosic feedstocks would be inexpensive, so experts expect equal or lower costs in the long run. Advanced bioethanol technology will supplement rather than replace corn-grain ethanol by greatly expanding the potential feedstock supply and making ethanol production an option outside the Corn belt. The U.S. Department of Energy National Biofuels Program is spearheading the effort to improve advanced bioethanol technology.

Biodiesel

B100 (pure biodiesel) can cut carbon monoxide, hydrocarbons, particulates, and other pollutant emissions in half while reducing the cancer-risk contribution of diesel by about 90 percent. Emission reductions with B20 are roughly proportional. Biodiesel will even reduce the smelly oily smoke that makes it so frustrating to get caught behind a diesel truck or bus.

For Fleets

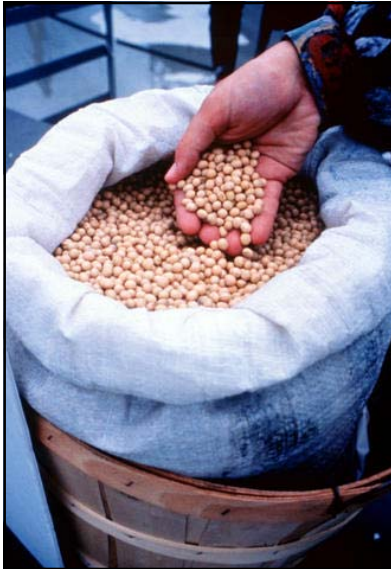
Although EPA's alternative fuel vehicle purchase requirements for state and federal fleets do not apply to heavy vehicles, fleets can receive credit for using biodiesel (2,250 gallons of B20 equals one alternative fuel vehicle

purchase) and fleet managers may use those credits for up to half of their alternative-fuel light-duty vehicle purchases. All other alternative fuels require expensive purchases for new vehicles, so using B100 or B20 can save fleets a lot of money—while substantially reducing pollution. For city busses and other highly visible fleets, switching to biodiesel is an easy way to make

Highly visible fleets, such as these city buses, can make an important statement about renewable fuels. Photo: NREL/PIX 06207.



an important statement of concern about air quality and customer health.



From Fats or Oils

Fatty acid methyl ester, commonly known as biodiesel, is made by bonding alcohol (commonly methanol) to oils or fats (even animal fats or used cooking oil). The process is relatively routine, but must consistently achieve prescribed standards adopted by the American Society for Testing and Materials (ASTM) to minimize the risk of damaging expensive diesel engines.

Half of U.S. biodiesel production capacity is designed for soybean oil, and half for recycled restaurant cooking oil, earning biodiesel a reputation for having a pleasant

french-fry smell. Because of incentives from a U.S. Department of Agriculture program supporting commodity purchases for increased biofuel production, 2001 U.S. biodiesel production was predominantly from soybean oil, but once the effect of the commodity program is over, the two main sources are likely to balance out. Both soybean oil and recycled restaurant cooking oil are currently in surplus, and biodiesel production uses only a small portion of each, so there is no resource constraint.

From a Growing Industry

Biodiesel popularity is growing rapidly, with U.S. production increasing from about five million gallons in 2001 to more than 450 million gallons in 2007. Most of the biodiesel producers are expanding and many more facilities are in the planning stages. Also, the detergent and fatty acid industries, which supply methyl esters to the biodiesel industry and can provide extra supplies when demand grows quickly, could provide another 30-50 million gallons of capacity, if needed to meet demand. Biodiesel is generally more expensive than diesel fuel, but B20 typically costs only 8 to 20 cents more than regular diesel. Although usually used by centrally fueled fleets, biodiesel is becoming increasingly available at retail service stations across the country.

As of 2007, Arkansas has two biofuels plants that have the capacity to produce about 27 million gallons of biodiesel per year. The Arkansas Farm Bureau identifies Arkansas biodiesel suppliers or fueling stations at www.arfb.com/commodity/biodiesel.asp?county=Arkansas.

Soybeans can be made to fuel any vehicle currently running biodiesel with little to no conversion of the vehicle.

Photo: NREL/PIX 07621.

Regulations and Incentives

An **income tax credit** is available to biodiesel suppliers for up to five percent of the costs of the facilities and equipment used in the wholesale or retail distribution of biodiesel fuels. The credits may be carried forward for three years. The cost does not include land, taxes, or services. (Reference: Arkansas Code 15-4-2104 and 2105.)

A biodiesel supplier is entitled to a **tax refund** equal to fifty cents for each gallon of biodiesel fuel that is used by the supplier to produce a biodiesel mixture that contains not more than two percent biodiesel and that is for sale by the supplier or for use by the supplier in a trade or business. (Reference: House Bill 2657, 2005 and Arkansas Code 15-4-2803.)

Federal

To encourage ethanol use, the federal government exempts 5.3 cents per gallon of 10-percent ethanol blend (53 cents per gallon of ethanol) of the 18.3 cents per gallon federal fuel excise tax. In effect since 1979, this credit makes ethanol competitive for fuel additive use.

The Energy Policy Act of 2005 provides a **federal excise tax credit** for biodiesel as a tax incentive for petroleum distributors who blend biodiesel with diesel fuel into both on-road and off-road markets. The incentive equates to \$1.00 per gallon of biodiesel made from virgin vegetable oils (like soy) and animal fats, and 50 cents per gallon for biodiesel made from recycled oils. The current blenders tax credit is set to expire on December 31, 2008.

Newly purchased, qualified electric vehicles and clean-fuel vehicles (including gasoline/electric hybrids) are eligible for federal income tax incentives:

- Purchasers of **hybrid and advanced lean-burn diesel vehicles** can receive a federal tax credit of up to \$3,400. This will be capped at 60,000 vehicles per manufacturer and will expire in 2014. For medium and heavy hybrid trucks the tax credit will expire in 2009, and for lean-burn diesel vehicles, the tax credit will expire in 2010.
- **Alternative Fuel Vehicles** (only capable of operating on compressed or liquefied natural gas, liquefied petroleum gas, hydrogen, or any liquid at least 85 percent methanol by volume) and purchased before December 31, 2010, may be eligible for a federal income tax credit of up to \$4,000. For more information, visit www.fueleconomy.gov/feg/tax_afv.shtml.

Resources

- Arkansas Renewable Energy: www.arkansasrenewableenergy.org
- Arkansas Energy Office: www.arkansasenergy.org
- American Solar Energy Society: www.ases.org
- American Wind Energy Association: www.awea.org
- Directory of Arkansas Biofuels Suppliers: www.arfb.com/commodity/biodiesel.asp
- DOE Biomass Program: www1.eere.energy.gov/biomass/
- DOE Clean Cities Program: www1.eere.energy.gov/cleancities/
- DOE's Office of Energy Efficiency and Renewable Energy (EERE): www.eere.energy.gov
- DOE Alternative Fuels and Advanced Vehicles Data Center: www1.eere.energy.gov/afdc/
- DOE Wind and Hydropower Technologies Program: www1.eere.energy.gov/windandhydro/
- EERE Information Center: www.eere.energy.gov/informationcenter/
- Florida Solar Energy Center: www.fsec.ucf.edu
- HybridCenter.org: www.hybridcenter.org
- Interstate Renewable Energy Council: www.irecusa.org
- National Biodiesel Board: www.biodiesel.org
- Renewable Energy Access: www.renewableenergyaccess.com
- Renewable Fuels Association: www.ethanolrfa.org



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