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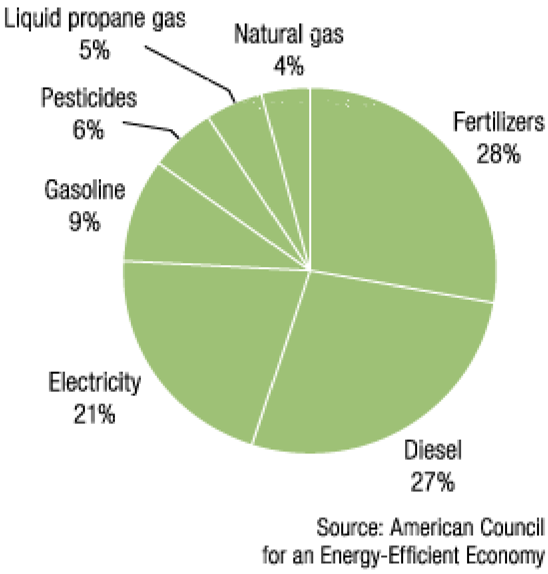
Managing Energy Costs in Agriculture

Energy usage in field crop–based agriculture has declined by about 28 percent since its peak in 1978, when the energy crisis and skyrocketing oil prices forced farms to begin to use energy more efficiently. Direct energy usage—a measure of annual on-farm consumption of gasoline, fuel, and oil, as well as utility charges for electricity, water, telephone, and Internet services—declined 26 percent, and the embodied energy in fertilizers and pesticides, known as indirect energy, has seen a slightly larger decline of 31 percent. **Figure 1** shows a breakdown, by energy source, for all farms.

Average energy use data

Figure 1: Total energy consumed by U.S. farms in 2002

Diesel fuel was the largest direct consumer of energy on farms, and fertilizers were the largest indirect energy user.



Top technology uses

- Drivepower
- Refrigeration
- Lighting

Direct energy accounts for 5 to 7 percent of farm expenditures; indirect energy accounts for 9 to 10 percent. Because small farms, especially, operate on profit margins well under 10 percent, efficiency measures that reduce energy costs can make a real impact.

In order to better manage your energy costs, it helps to understand how you are charged for those costs. Larger farms are typically billed as commercial customers by the utility, while many small farms are billed as residential customers. Most utilities charge their commercial customers for natural gas based on the amount of energy delivered, in therms. Electricity, on the other hand, is usually charged based on two measures—consumption and demand. In addition, many irrigation bills contain an additional base rate charge.

Base rate (or meter) charge. This is a monthly fixed fee that covers the cost of having metered access to an electric supply. It is similar to a telephone line charge that is separate from the number of minutes that you use. This fee may also be rolled into the consumption charge.

Consumption charge. Utilities measure electricity consumption in kilowatt-hours (kWh)—the number of kilowatts (kW) used in a one-hour period. A kilowatt-hour equals 1,000 watt-hours and can be thought of as ten 100-watt light bulbs burning for one hour. Consumption is measured using a kWh meter.

Demand charge. Utilities incur costs to have enough generation capacity (in kW) available to meet the needs of their larger customers during peak-use periods. During non-peak periods, this capacity sits idle but the utility still incurs maintenance, repair, and debt-repayment costs. These costs are assessed against commercial customers in addition to consumption charges. On the customer side, demand represents the size of the connected load rather than how many hours the system is operated. Utilities typically base the demand charge on either:

- *Fixed rate.* In this method, the nameplate horsepower (hp) ratings of all system components are added up and multiplied by a fixed dollar amount. This charge is added to the monthly consumption bill.

- *Maximum wattage.* This method measures the wattage used in 15-minute increments over the entire monthly billing period. The charge is based on the highest recorded wattage used during the month—that number is multiplied by a fixed dollar amount and added to the consumption bill. It is important to note that a monthly demand charge is incurred even if the system only runs for one 15-minute interval during the entire month.

There are many ways to cut demand, including installing more-efficient, lower-power equipment; staggering the start-up times of various pieces of equipment; and participating in utility demand-response programs.

Direct energy costs on crop farms typically represent up to 7 percent of the farm production costs. As you read the following energy cost management recommendations, keep in mind how each one will affect both your consumption and your demand. The conservation measures discussed for the short and longer terms represent good investments. Not only will they help you to save money on your energy bills, but they can also increase your competitiveness by cutting your costs.

QUICK FIXES

this section

Many crop farms can benefit greatly from low- or no-cost energy-expenditure reductions, such as turning things off, turning things down, keeping up with cleaning and maintenance, and performing system tune-ups.

Turning things off

It’s the simplest of ideas, and every 1,000 kWh you save by turning things off when they’re not in use cuts US$100 off your utility bill (assuming an average electricity cost of $0.10/kWh).

Lights. Turn off lights during the night when they’re not in use. Installing a timer, photocells (which turn lights on at dusk and off at dawn), or motion sensors on outdoor lighting systems can help with this task, although motion sensors may not be suitable for all applications. A less-expensive alternative is to train staff to ensure that switches are off when the lights aren’t needed, especially at the end of the day.

Air conditioners. Window air conditioners in outbuildings such as machine shops or garages are energy hogs, consuming up to 1 kW per hour on average. Consider installing a timer to shut the unit off when you’re not there and turn it back on a half-hour before you expect to return.

Turning things down

Some equipment cannot be turned off entirely, but turning it down to minimum levels where possible can save energy.

Reduce light levels. In spaces where natural lighting is available, dim lights in proportion to the availability of sunlight. Daylighting controls can make this easier by adding automation.

Install programmable thermostats. Turning your heating systems down and cooling systems up while buildings are unoccupied is a simple way to gain some energy savings. Choose a programmable thermostat that allows for multiple start/stop times to accommodate your schedule.

Cleaning and maintenance

Periodic cleaning and maintenance ensures good operating performance, helping equipment run at optimal levels.

Clean fans. Failure to clean fans and shutters, which provide ventilation and circulation in buildings such as machine shops, can reduce ventilation efficiencies by as much as 40 percent and will increase the possibility of fire. You should also lubricate any motor bearings and shutter pivot points with machine oil at least once a month to ensure optimal operation. Last, check fan blades regularly for any damage—replacing fan blades is much more cost-effective than replacing an entire fan. For more detailed information, see our article on maintaining air-handling equipment .

Keep lights clean. Clean lighting fixtures and bulbs to ensure that they continue to perform as designed and provide acceptable light levels for workers to perform their tasks.

Replace belts. Belts are often used to transfer power from motors to pumps and fans. Standard V-belt drives can be found in the majority of belt applications. They are the lowest-cost option of the belt family, but they're also low in efficiency. New V-belts typically achieve efficiencies in the 90 to 95 percent range, but a worn belt's efficiency can be considerably reduced due to slippage caused by slackening and worn grip surfaces. Cogged V-belts are similar to standard V-belts, except that the normally flat underside has longitudinal grooves in it, allowing better grip and less slip than standard V-belts. Cogged V-belts typically offer a 2 to 5 percent efficiency bonus over standard V-belts.

Perform system tune-ups

Systems that are used seasonally, such as irrigation and crop-drying equipment, should be tuned up at the beginning of each season for optimal performance and thoroughly cleaned and lubricated at season's end to prevent deterioration during periods of dormancy.

Tune up irrigation equipment. Keep engines serviced and well-tuned, and keep electric motors, switches, and control panels free of dirt, insects, and bird nests. Check connections for tightness and lubricate moving parts as needed. Check for correct impeller alignment, worn nozzles and shaft sleeves, leaking gaskets and drains, and dried-out pump packing and bearings. Clean and lubricate as needed at season's end.

Test the well pump. Local utilities or water agencies will often test pumps free of charge or at low cost. Depending on the level of pump efficiency the test shows, you can:

- Adjust the impeller (between 55 and 60 percent pump efficiency)
- Adjust the impeller, and if no improvement is noted, repair or replace the pump (between 50 and 55 percent)
- Repair or replace the pump (less than 50 percent)

Tune up the drying system. If you have a crop-drying facility, be sure to clean screens and aeration floors, check belt drives (make sure safety guards are in place), clean fan housings and blades, calibrate temperature-sensing devices, clean and check burners for proper operation, have utility personnel check gas-pressure regulators, and have any grain-moisture testers and sensors calibrated annually. Clean all debris from screens, aeration floors, and fan housings and blades at season's end.

LONGER-TERM SOLUTIONS

this section

Although the actions covered in this section require more-extensive implementation efforts, they can dramatically increase the energy efficiency of your farm without compromising productivity. Ask your local utility representative for more information about funding or guidance that might be available for such projects.

Irrigation

Pumping water to irrigate crops can account for as much as 30 percent of a farm's total energy use. Energy and cost savings are possible by implementing efficiency technologies.

Motors. Improve motor efficiency by rebuilding existing motors or by upgrading to premium-efficiency models . Rebuilding old motors can improve efficiency by a few percentage points. Motor shops will install new bearings, rewind the core, and "dip and bake" the motor (to keep the core electrically insulated). When upgrading, keep in mind that premium-efficiency motors cost more initially but more than make up for the cost in energy savings, higher service factor, longer bearing and insulation life, and lower vibration levels. Consider purchasing a premium-efficiency motor when the cost of rebuilding the existing motor exceeds 65 percent of what it would cost to replace it. Some premium-efficiency motors draw a larger start-up current, so verify that your system has the appropriate capacity before you buy, and remember that the cost of electricity to operate a motor for its lifetime far exceeds its purchase price.

Drives. Installing variable-speed drives on irrigation pumps cuts energy use for a variety of reasons. Pumps are often oversized and therefore don't operate at their most efficient speeds. Flow-rate requirements change over time, and in a single-speed system, the only options are to bypass the extra flow or dissipate the extra pressure that builds up at the lower flow rate. Either way, energy is wasted. A variable-speed pump, however, will reduce energy use when flow rates are low, and will allow the pump to start and stop more slowly, reducing the potential for cavitation, a condition in which air bubbles form and collapse, producing potentially damaging shock waves inside the pump.

Pumps. Rebuilding old pumps can be a cost-effective way to improve efficiency. This process involves replacing shaft sleeves, wear rings, and packing, as well as machining or replacing the impeller. However, if the existing pump is oversized or undersized, it should be replaced with a unit that matches the system requirements.

Irrigation scheduling. This computer-controlled tool—consisting of sensors, hardware, and software—allows farmers to track the moisture available to the crop and to more-accurately forecast the crop's moisture needs. By irrigating crops only when necessary, farmers can often reap enough savings on water, energy, fertilizers, and labor in the course of a year to pay back the cost of the irrigation scheduling tool.

Centrifugal pumping system fittings. Undersized fittings are often used to connect a pump to the mainline distribution pipe because they have a lower initial cost. Unfortunately, any abrupt change in diameter can cause increased friction losses, resulting in significantly higher pumping costs. Next time you rebuild your pump, consider these fitting guidelines to achieve maximum pumping system efficiency:

- Install a concentric expansion joint on the pump discharge to create a smooth transition from the smaller pump outlet diameter to the larger mainline distribution pipe diameter.
- Ensure that the check and shut-off valves are the same diameter as the mainline distribution pipe.
- Use a flexible joint of the same diameter between the shut-off valve and the mainline distribution pipe. This will minimize friction losses from misalignment, axial movement, and thermal expansion.
- Install a pipe support just downstream of the flexible joint to minimize pipe movement.

- Install the discharge pressure gauge downstream of the expansion joint. Use a ball valve to isolate the gauge to facilitate winter removal.

Surface-water pumping. Energy-efficient pumping from rivers or canals requires adherence to several design parameters. Here are some guidelines to help you determine whether your system is operating as efficiently as possible.

On the suction side of the pump, which pulls water from the source:

- Ensure that pipe joints are airtight under vacuum conditions
- Eliminate any high spots where air can collect
- Ensure that the suction lift (the distance from the pump impeller to the water surface) is no more than 15 to 20 feet
- Use an eccentric reducer at the pump inlet to prevent air from being trapped in the reducer

On the discharge side of pump, which delivers pumped water for distribution:

- Ensure that the shut-off valve is the same size as the mainline pipe
- Verify that the check valve is a “non-slam” type to prevent the pump from spinning backwards on shutoff
- Ensure that there is an air-relief valve if the mainline distribution pipe is buried
- Shade the motor to reduce the potential for overheating

Center-pivot systems. Switching to flexible hose drops—so that water is dispensed no more than a few feet above the crop—reduces evaporative losses and drift from the wind. Even higher efficiency can be attained with low-energy precision applicators (LEPAs), which deposit the water very close to or directly on the ground between crops. LEPAs allow 95 to 98 percent of the pumped irrigation water to get to the crop.

Drip and microirrigation systems. In this type of system, emitters are placed on the ground so that the capillary action of the soil brings water to each plant’s root zone, reducing the amount of water and energy required for effective irrigation. Drip systems may also be buried, so that they deliver water directly to the roots. Both surface and subsurface drip systems can effectively deliver nutrients directly to the plants, improving yields and reducing fertilizer use.

Additional guidelines and line drawings can be found in Energy Saving Tips for Irrigators , a publication of the National Sustainable Agriculture Information Service .

Crop drying

After harvesting, most field crops go through on-farm processing steps that require additional energy use before they are sold. The most common process, for crops with high moisture content, is drying. Drying brings the crops to specified moisture levels for storage and processing. Grain-drying systems typically use electricity to run fans and move grain, and they use propane or natural gas to provide heat. There are a wide range of opportunities to make crop drying more efficient; corn requires more energy for drying than any other grain, so we’ve used it as an example, though these processes will work for most harvests.

Ambient air drying. If a corn crop comes out of the field at less than 22 percent moisture, consider using ambient air—also called low-temperature—bin drying. This process uses the drying potential of air to replace the fuel energy supplied by propane or natural gas, and it takes place over a longer period of time. Electrical energy use increases, however, because more air needs to be moved at lower temperatures. Tests in Wisconsin and Ohio have shown that, in those regions, the process uses one-quarter to one-half the energy of a typical cross-flow high-temperature dryer.

Combination air drying. To reduce some of the risks with ambient air drying, such as unexpected and persistent humid weather, use a high-temperature dryer to dry corn down to about 20 percent and then finish with ambient air or a low-temperature bin dryer. Transfer the hot grain to the bin dryer and start the aeration fans immediately. This practice can reduce energy requirements by up to 60 percent compared to combustion drying alone, and it can improve grain quality because it can result in fewer cracked kernels than high-temperature drying processes.

Heat recovery. If you are using a cooling section on your continuous-flow dryer, adding heat recovery (to capture the hot air being exhausted from the cooling system and reintroduce it into the burner) can save 10 to 15 percent in energy use. Heat recovery can also be added to the lower portion of a continuous-flow dryer’s heating column by capturing the exhaust air that is not yet saturated and reintroducing it into the burner. This process can save an additional 5 to 10 percent in heating costs. Heat recovery can also be added to the lower section of full-heat dryers for a 5 to 10 percent energy savings.

In-bin cooling. After drying, crops need to be cooled. You can save fuel by cooling corn in the storage bin instead of in the dryer. Although rapidly cooling corn in a dryer does not remove any additional moisture, corn that is unloaded from a dryer while it's still hot and transferred to storage where it's cooled slowly by the storage bin's aeration fan will lose 1 to 2 additional percentage points of moisture. This means that if the final moisture target is 15 percent, the dryer can be unloaded when the corn reaches 16 to 17 percent moisture. In-bin cooling saves heating fuel and increases dryer capacity because corn can be removed sooner.

Dryeration. An alternative to in-bin cooling, dryeration entails adding a special bin as an additional step between the dryer and the storage bin. In the dryeration bin, kernels to lose 2 to 3 percentage points of moisture as the corn tempers (steaming in its own vapor) for 4 to 10 hours, before the cooling fan is started. Delaying cooling reduces energy use, speeds up drying time, and improves corn quality (better test weight and fewer cracked kernels).

Stirring device. Adding a stirring device to the grain bins will loosen the grain and increase airflow through the mass, resulting in an increased drying rate. It also mixes dry grain from the floor of the bin with high-moisture layers higher up, decreasing drying time. Studies from the University of Wisconsin suggest energy-use reductions of as much as 20 to 30 percent can be achieved when grain stirrers are used.

High-efficiency dryer models. If ambient air drying is not an option, consider replacing your existing cross-flow grain dryer with a continuous in-bin dryer—the most efficient type of high-temperature dryer. Because cross-flow dryers use high velocities to blow air all the way across the large but shallow layer of grain, the air is traveling too fast to become fully saturated, which wastes a portion of the fan power. Continuous in-bin dryers work on a much smaller cross-section of the bin and thus are able to exhaust fully saturated air. They use about 40 percent less energy than a typical continuous cross-flow dryer does.

Solar-assisted heating. When added to a low-temperature dryer, solar-assisted heating, which uses solar-heated air to dry the stored grain, has been shown to reduce drying time and energy costs by 9 to 13 percent in a study conducted by Iowa State University.

Dryer controls. Updating your high-temperature dryer controls to two-stage burners and modulated burners can save energy by reducing the extreme temperature variation caused by on/off thermostatic controls. Moisture and temperature sensors placed in the grain can save energy by sensing when the grain is dry enough to be removed from the dryer, which also reduces overdrying.

Computerized control systems. Computerized controls offer more-precise moisture and energy-management capabilities than manual systems by regulating the temperature of the dryer's air based on the crop's moisture level. Additionally, the systems are automated—so farmers can work on other tasks and not worry about constantly checking and adjusting temperature levels.

Low-profile drying bins. Low-profile bins are shallower than conventional bins, and although they have a larger footprint and take up more space, they save energy and reduce costs by decreasing airflow resistance through the grain, reducing fan-power requirements, and speeding drying time. Typically, reducing the drying depth by one-fourth will reduce the energy cost per bushel by one-third.

High-efficiency motors. Using high-efficiency motors and sizing the system to match the flow rates will reduce energy use.

Additional guidelines and line drawings can be found in the Low-Temperature and Solar Grain Drying Handbook , a publication of the Iowa State University Midwest Plan Service; Natural Air Corn Drying for the Upper Midwest , a publication of the University of Minnesota Extension Service; and Dryeration & Bin Cooling Systems for Grain , from Purdue University Cooperative Extension Service.

Lighting

Energy-efficient lighting is a simple solution to reducing energy costs in all of your buildings.

Compact fluorescent lamps (CFLs). CFLs can replace incandescent lamps in many applications, and this change can reduce energy use by 75 percent—a savings of up to $20 per lamp per year—and increase lamp lifetime by 6 to 10 times.

Pulse-start metal halide (MH) lamps. If your farm uses old probe-start MH lamps, replacing them with pulse-start MH lamps can cut energy use by at least 10 percent. In addition, the pulse-start lamps last longer, maintain their light output at higher levels, and start up more quickly than probe-start lamps do.

Outdoor yard lights. When selecting outdoor lights, consider fluorescent lamps , low-wattage MH, or high-pressure sodium (HPS) lamps rather than mercury vapor lamps. Both MH and HPS lamps are far more efficient than mercury vapor lamps, which have effectively been banned by recent federal legislation. MH lamps are less efficient than HPS lamps in conventional terms, but MH lamps put out more light in the blue part of the spectrum, which is easier for our eyes to see under low-light conditions. This allows for the use of a lower-wattage MH lamp. Fluorescent lamps can be used outdoors as long as their ballasts are rated for cold-weather starting. Light-emitting diodes (LEDs) are also becoming a viable option for outdoor lighting. LEDs are expensive but can offer good efficiency and long life—though be sure to evaluate LED products carefully because manufacturers often exaggerate performance.

Photocells and timers. Install lighting controls such as photocells or timers on outdoor lighting. A photocell control will turn on a light at dusk and turn the light off when the photocell detects daylight. Newer photocells are able to dim lights or turn them off in the middle of the night if they are no longer needed.
