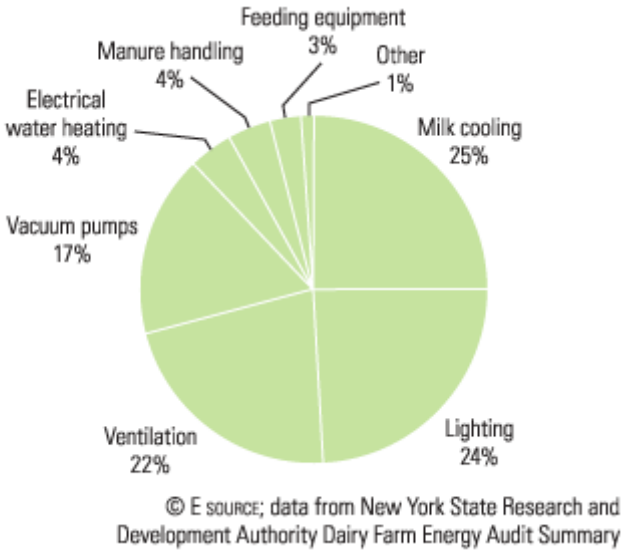
Managing Energy Costs in Dairy Farms

Energy usage on dairy farms has grown gradually in the past 20 years due to increases in farm sizes, use of automated equipment, and around-the-clock operation. Dairy farms in the U.S. typically consume between 800 and 1,200 kilowatt-hours (kWh) per cow annually. About 50 percent of the total energy used on a dairy farm goes toward milk-production equipment, which includes milk cooling, vacuum pumps, and water heating. Lighting and ventilation account for most of the remainder of energy used (**Figure 1**).

Average energy use data

Figure 1: Energy consumption by end use

Half of the total energy consumed on dairy farms is used for milk-production purposes—cooling, pumps, and water heating. Lighting and ventilation systems primarily consume the remainder of the total energy used.



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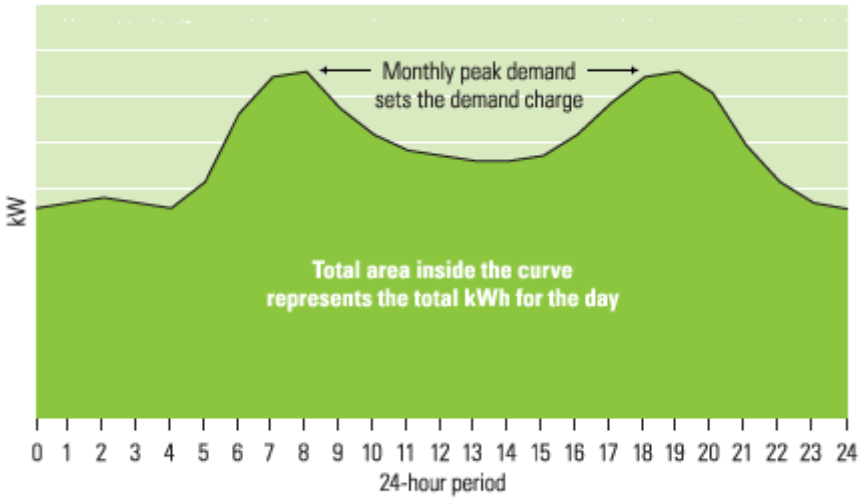
Top technology uses

- Refrigeration
- Lighting
- Ventilation

In order to better manage your dairy farm's energy costs, it helps to understand how you are charged for those costs. Most utilities charge commercial customers for their natural gas based on the amount of energy (in therms) delivered. Electricity, on the other hand, can be charged based on two measures—consumption and demand (**Figure 2**).

Figure 2: Diagram of a hypothetical daily load shape

Peak demands on dairy farms typically occur during milking periods. Most dairy farms will milk twice per day—once in the morning and once at night—but some dairy farms have three milking periods: morning, midday, and nighttime.



The consumption component of the electricity bill is based on the amount of electric energy, in kilowatt-hours, that the building consumes during a month. The demand component is the peak power, in kilowatts (kW), drawn by the farm during each month or, for some utilities, during the previous 12 months. Demand charges can range from a few dollars per kilowatt-month to upwards of $20 per kilowatt-month. Because demand can be a considerable percentage of your bill, you should try to reduce peak demand whenever possible. As you read the following energy cost management recommendations, keep in mind how each one will affect both your consumption and your demand.

QUICK FIXES

this section

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

Turning things off

It’s the simplest of ideas. Remember that every 1,000 kWh you save by turning things off equals US$100 off your utility bill. (This assumes an average electricity cost of $0.10/kWh.)

Lights. Turn off lights during the night when they're not in use. Installing a timer, photo controller, or motion sensor on lighting systems can help with this task, although motion sensors are not suitable for barn applications. A less-expensive alternative is to train staff to ensure that switches are off when the lights aren't needed and, especially, at the end of the day.

Fans. Cows typically begin to get heat stress at 74° Fahrenheit (F) with a 75 percent humidity level, so shut off fans when temperatures get below 70°F. Installing thermostats in the barn can help with this task.

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.

Raise refrigeration temperatures. Keep your refrigeration units set at the appropriate temperature—but no cooler than necessary.

Reduce pressure on compressors. Drop the pressure on your compressors to a level that meets your needs. Reducing your compressor setpoint by 20 pounds per square inch can reduce compressor energy costs by 10 percent. By reducing system pressures, you will also be reducing system leak rates and increasing the life of your equipment.

Reduce water heater temperatures. Turning water heater temperatures down by 10°F will decrease water heating costs by 3 to 5 percent. However, be sure to keep temperatures above process requirements—for example, washing systems typically require water temperatures to be at least 120°F.

Cleaning and maintenance

Clean heat exchanger coils. The heat exchangers in milk-cooling systems are designed to be opened and cleaned on a quarterly basis. Cleaning condenser coils alone can reduce milk cooling costs by 3 to 5 percent.

Clean fans. Failure to clean fans and shutters, which provide ventilation and circulation, can reduce ventilation efficiencies by as much as 40 percent and will increase the possibility of

fire hazard. 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 they continue to perform as designed (especially if you use dimmers). Maintaining lighting equipment will also provide acceptable light levels for workers to perform their tasks.

Check water heaters. Minimizing corrosion can boost water heater efficiency. If required, anode rods (located inside the water heater) can be replaced to increase the water heater's lifetime. Gas combustion burners should also be inspected annually. An easy way to do this is to open up the combustion chamber hatch: If the combustion chamber is blackened, call a technician to take a look.

Conserve water. Another effective way to reduce water heating costs is through water conservation. Having your dairy equipment dealer tune up your pipeline washing system can reduce the amount of water required for washing dairy equipment, which in turn reduces your water heating loads.

Check pumps. Pumps should be cleaned and maintained periodically to sustain good operating performance. Motors in pumps that have accumulated dust can overheat, which will decrease the efficiency and lifetime of the pumps, and can become fire hazards. Also, poor contact on motor power terminals can result in premature motor failure. Check power terminals monthly to make sure that they remain tight.

Replace pump and fan belts. Belts are often used to transfer power from the motor 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. The tradeoff is reduced energy efficiency. New V-belts typically achieve efficiencies in the 90 to 95 percent range. A worn belt, however, can considerably reduce the efficiency 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. They typically offer a 2 to 5 percent efficiency bonus.

LONGER-TERM SOLUTIONS

this section

Although the actions covered in this section require more extensive implementation efforts, they can dramatically increase the efficiency of your dairy farm without compromising speed or reliability. Ask your local utility's representative for more information about initiating such projects.

Refrigeration

Milk cooling is an energy hog in dairy facilities. There are a couple of high-efficiency refrigeration technologies that can reduce energy consumption.

Scroll compressors. Dairy farms have traditionally used reciprocating compressors for milk-cooling systems, but in the last 10 years, they have started to utilize scroll compressors, which can reduce compressor energy costs by as much as 20 percent when compared to traditional reciprocating compressors. In addition to being more energy efficient, scroll compressors are also quieter and produce less vibration because there are no valves and only one moving part.

Refrigeration heat-recovery systems. Heat-recovery systems reduce energy costs by recovering waste heat that typically gets discarded by the milk-cooling condenser units. The recovered heat is then used for preheating water that is used for washing milking equipment. As an added bonus, heat-recovery systems also increase the refrigerator's heat-exchanger efficiency because heat-transfer rates are higher between refrigerant and water than between refrigerant and air.

Water-cooled precoolers. Using well-water heat exchangers to precool milk before it enters the refrigerated milk tank can reduce milk-cooling costs by up to 60 percent because heat exchangers can drop the milk's temperature by as much as 30°F. To ensure that plate precoolers are performing at an optimal level, check that the well-water lines are sized correctly. In addition, if you already have a refrigeration heat-recovery system in place, check that a water-cooled plate cooler will not negate the cost benefits of the heat-recovery system (plate coolers will reduce the amount of heat generated by refrigerated milk tanks). When weighing the benefits of heat-recovery systems versus water-cooled plate coolers, it is best to conduct an energy audit to analyze the cost benefits. It is often more cost-effective to install a heat-recovery system, especially on farms with smaller refrigeration loads, because it is less expensive to cool milk than it is to heat water. However, in large farm applications (150 cows or more) where refrigeration loads are larger, it might be cost-effective to use a plate cooler in addition to a heat-recovery system.

Pumping

Pumping systems consume almost a fifth of all the energy on dairy farms. When purchasing pumps, be sure to size them correctly—oversized pumps will result in increased energy consumption.

VSDs for pumps. Variable-speed drives (VSDs) use integrated controls and sensors to operate the drive at the lowest possible speed to perform the required job. The savings from VSDs add up quickly because the power needed to drive a pump is proportional to the cube of the motor speed. Depending on the size and operation of the farm, purchasing VSDs for vacuum pumps and milking pumps could prove to be economical, though smaller farms—those with fewer than eight hours of milking per day—may not be able to offset the capital costs of VSDs with energy savings. In most dairy farm applications, replacing constant-speed pumps with VSD pumps can reduce pumping energy consumption by half.

Water heating

Heat-recovery systems. As mentioned above, an efficient way of heating water on dairy farms is by recovering heat energy from the refrigeration condenser units. Up to 50 percent of a farm's water heating requirements can be met through heat-recovery systems.

High-efficiency water heaters. The thermal efficiency of water heaters varies greatly depending on the water heater type. Though electric water heaters can operate at nearly

100 percent efficiency, oil and gas water heaters will typically have lower operating costs because the fuel costs less than electricity. Conventional oil and gas water heaters will have a thermal efficiency of about 80 percent. When looking to save energy in water heating, consider purchasing a high-efficiency condensing oil or gas water heater, which recover more of the heat from the combustion gases. Condensing water heaters have thermal efficiencies of more than 95 percent.

Ventilation

Supplying air to dairy cows at the right temperature and humidity can increase the productivity of the farm—heat stress can drop cows' milk production by 20 to 30 percent. In addition, because cows can get pneumonia in cold and humid environments, humidity sensors and controls should be installed that will turn fans on when humidity levels are high and temperatures drop below freezing.

High-efficiency fans. Ventilation energy costs on dairy farms are dependent on the efficiency of the fans. When looking for new fans, be sure to pay attention to the air-circulation system design, the blade design, and the level of efficiency. One solution is to use high-volume, low-speed fans, which provide widespread air movement but consume much less energy and produce less noise than high-speed fans.

Controls. For optimal ventilation, fans should be controlled by programmable thermostats . Install the thermostat in a location that will measure air temperature and be sure to clean the thermostat regularly to prevent dust buildup.

Lighting

Energy-efficient lighting is a simple solution to reducing energy costs, especially when the technique of long-day lighting—in which lights are left on for 18 hours a day to increase milk production—is implemented.

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

T8 fluorescent lamps. If your dairy farm uses T12 fluorescent lamps, relamping with modern, electronically ballasted T8 lamps can reduce your lighting energy consumption by 20 percent or more. These lamps should be enclosed in water-resistant fixtures. Adding specular reflectors, occupancy sensors, or timers can more than double the savings.

Paybacks of one to three years are common. For more information, see our article on fluorescent lamps .

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

Outdoor yard lights. When selecting outdoor lights, consider fluorescent lamps, low-wattage metal halide (MH) or high-pressure sodium (HPS) lamps rather than mercury vapor lamps. These 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.

Photocells and timers. Install 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. For more information, see our article on lighting controls .

Anaerobic digesters

Anaerobic digestion is a solution to managing agricultural waste from cows that can also reduce energy costs. In addition to providing a treatment route for manure with fertilizer as an end product, running a generator off the produced biogas brings in revenue for the farm. Estimates show that dairy anaerobic digesters could produce between 4 and 5 kWh per cow per day. With concentrations of more than 100,000 cows at some operations, the potential energy resource is huge. For more information on anaerobic digestion, refer to the U.S. Environmental Protection Agency's Guide to Anaerobic Digesters or the fact sheet, Anaerobic Digester—Controlled Temperature (PDF), created by the Natural Resources Conservation Service.