Dairy Farm Energy Management Handbook

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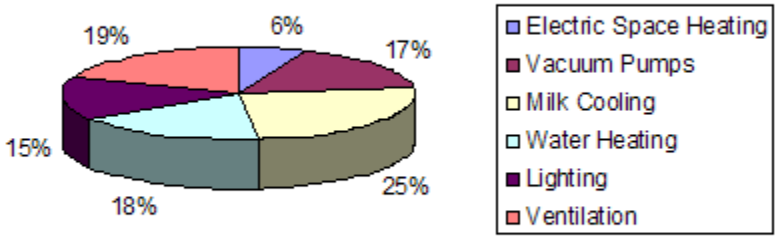
Introduction

Closely examining and controlling energy costs are very important management strategies in dairy farming. Implementing and sticking with those strategies will become even more critical in future efforts to help buffer the expected price fluctuations of electricity, natural gas, and other fuels.

You don't need to search long or hard to find cases where profits drain away quickly when out-of-pocket energy expenses and frequent equipment replacements are allowed to mount unchallenged from one year to the next.

Such expenses often come as no big surprise since dairy facilities – equipped with a wide variety of motors, pumps, compressors, fans and lighting – consume energy daily, and this constant demand still accounts for a notable share of production costs.

Energy Use by Equipment Category on Wisconsin Dairy Farms



Source: Energy Center of Wisconsin, *Efficiency and Customer-Sited Renewable Energy,* ECW Report Number 235-2, Oct. 2005

That's why a comprehensive energy plan remains your best ally in operating more efficiently and economically. It's also very important to periodically assess the condition and safety of your wiring system.

A good plan can help you examine, manage and control costs and offer useful guidelines about regular equipment operation and maintenance to enhance safety and reliability.

Helping you reach that goal is a key reason why this handbook on dairy farm energy management was developed.

This handbook serves as a handy energy operation and maintenance management guide. You'll find suggestions on ways to reduce energy costs and enhance electrical safety. Some regular and preventative maintenance tips to keep equipment operating efficiently, safely, and to help conserve energy are also available in the handbook.

Developing an energy management and equipment maintenance plan doesn't have to be overly complicated, especially if you take the time to arm yourself with some facts and learn more about what current options are available that can help lessen the sting from energy costs and help you maximize profits.

For example, numerous equipment upgrade options exist which can be applied in a fairly short time. Better and more efficient lighting fixtures, high efficiency water heaters and electric motors are just a few examples of what choices are available to you today.

Making those choices is also fairly simple because research and studies have closely examined energy usage on farms and evaluated what changes make the best economic sense in terms of payback.

A proactive plan to regularly check or service equipment and make necessary repairs on a scheduled basis will more than pay for itself when compared to having to do the same work in a crisis or hurried situation.

The general rule is that for every dollar spent on preventive maintenance, you will save at least five dollars in subsequent expenses. **(1)**

Better energy management can also impact milk production in a positive way, as well as help you increase net returns in dairying by keeping equipment operating at optimal conditions.

Good energy management also makes sense from a safety standpoint, especially when it involves examining and maintaining the wiring system to keep it in top-notch condition. For example, some insurance industry reports have shown that more than 12% of farm fire losses (property and personal injuries) involve the electrical system.

This is why you're strongly encouraged to take advantage of the utility's expertise in evaluating your existing wiring infrastructure and electrical equipment to make sure that it's safe, up-to-date, and operating efficiently and properly.

In Wisconsin, all utilities offer a combination of rebates, grants and loans to help offset the cost for rewiring agricultural facilities.

While every aspect of energy management can't be covered here, this handbook will attempt to highlight some important points about farm energy audits, wiring, cooling milk and water heating, ventilation, lighting and electric motors. They all represent key areas to consider in your quest to manage and conserve energy.

In addition, you will also find key contact and resource information in the appendix section at the back of this handbook, if you wish to pursue energy topics in more detail.

Note: This Dairy Farm Energy Management Handbook was prepared by Karl Ohm, an agricultural and natural resource journalist/photographer, based in Menomonee Falls, Wis., in cooperation with the WDATCP and the Rural Energy Management Council (REMC).

Farm Energy Audits

The first step towards sound operation and maintenance management:

Working with your local power utility on a farm energy audit is one of the most important first steps to take in understanding how to manage energy more efficiently. Photo: Karl Ohm

On the surface, utility costs may seem small in comparison to feed and other items associated with dairy farming; however, if left unchecked, using energy inefficiently or unwisely generates unnecessary costs that can quickly add up and impact your bottom line.

Dairy farms in Wisconsin typically spend an average of $62 to $96 per cow per year on energy (2003), which includes electricity, natural gas, LP gas and heating oil, according to the University of Wisconsin-Extension.

In 2003, dairy producers in the state spent an average of slightly more than $8,574 – or about $101 per head (2004) – on utilities. Expressed in another way, this equates into about .38 cents per hundredweight (cwt.) of milk.

According to estimates, electricity alone accounts for 2 to 5% of a dairy farm's production costs. This translates to annual electricity use of 700 to 900 kilowatt-hours (kWh) per cow or 3.5 to 4.5 kWh per cwt. of milk produced.

Utility Costs versus Farm Size

Herd Size	Avg Cost/Cow	Max/Min
50 or less	$96	$191.73/10.78
51 to 75	$95	$185.25/19.03
76 to 100	$94	$129.74/27.24
101 to 150	$84	$106.86/23.77
151 to 250	$71	$106.86/32.13
251 or more	$62	$100.48/10.33
2003 study by Jenny Vanderlin - Milk Production Costs on Selected Wisconsin Dairy farms (Center for Dairy Profitability). Utility costs include: electric, LP gas, natural gas, and heating oil.		

But since each dairy farm may face different circumstances, it is very important to start with an energy audit that can help provide a snapshot view of your current situation.

The farm energy audit will serve as a meaningful reference point upon which better decisions and comparisons can be made about equipment upgrades and wiring issues and what changes may offer the quickest paybacks.

Such paybacks will obviously occur more quickly in those key areas that normally use the most energy on your dairy farm.

On most dairy farms in Wisconsin, milk cooling accounts for the lion's share of electricity usage at 25%, followed by ventilation at 19%, water heating at 18%, vacuum pumps at 17%, and lighting at 15%. Electric space heating and miscellaneous uses accounted for another 6% of electricity usage. **(2)**

"Getting an energy audit done on your farm is an important first step to take in developing a comprehensive energy management plan."
-- Scott Sanford, Senior Outreach Specialist with the University of Wisconsin's Rural Energy Program.

Dairy farms in other states also show similar energy demands. For example, according to the Dairy Farm Energy Audit Summary in New York, milk cooling, lighting, ventilation, and vacuum pumps are the top four categories that accounted for 88% of all electrical energy used on all of the audited farms.

Breaking this down further, milk cooling's share totaled 25%, followed by lighting at 24%, ventilation at 22%, and vacuum pumps at 17%. Electric water heating (4%), manure handling (4%), feeding equipment (3%), and miscellaneous (1%) made up the balance of 12%.

So, an energy audit is well worth the effort since experience has already shown that dairy producers can save 10 to 40% – or more, in some cases – by using reliable energy-efficient technology in their milking, milk cooling, and water heating processes, according to the University of Wisconsin - Madison.

"Getting an energy audit done on your farm is an important first step to take in developing a comprehensive energy management plan," says Scott Sanford, senior outreach specialist with the University of Wisconsin's Rural Energy Program.

The proper sizing of barn fans and well-functioning louvers may also be included in a comprehensive farm energy audit plan. Photo: Karl Ohm

An energy audit will help lead the way to better management, and the best place to start is to contact your power utility or the Wisconsin Focus on Energy program **(Appendix)**.

The energy audit may also help pinpoint other areas requiring attention. For example, vacuum pumps not maintained properly, poor lighting conditions, or improperly sized ventilation fans are just a few factors that can influence cow comfort and behavior and ultimately milk production.

So, while these costs don't directly show up as line items on the utility bill, sooner or later they will creep in and shrink your margins.

Also, many energy management recommendations made by these audits are often linked to rebates or low interest loan programs within the Wisconsin Focus on Energy program or your local utility, according to Rich Hasselman, an energy consultant with GDS Associates, of Madison, a firm that helps perform audits for this program.

Farm Wiring

From transformers and circuit breaker boxes to wiring, switches and outlets, there's no question that the electrical wiring infrastructure is the backbone of your farm's energy system.

However, many farm buildings are still in use today that date back to the '40s and '50s, and the electrical systems have, in many cases, outlived their usefulness and may be unsafe and inefficient.

According to a recent survey of 8,600 dairy producers by the Wisconsin Agricultural Statistics Service (WASS), about 31% of the respondents in the state indicated their wiring was 20 to 29 years old. Twenty percent said that their wiring was 30 or more years old; 23% said that their wiring was 10 to 19 years old, and 26% indicated wiring age at 0 to 9 years.

The good news is that you can get a free, annual wiring checkup from your utility to pinpoint those areas that may need upgrading or replacement. Conducting a thorough wiring checkup is recommended at least every two years, according to the Rural Energy Management Council (REMC).

Enhancing electrical safety and improving power quality and equipment operation are some key reasons for considering rewiring and upgrades. Wiring to the National Electric Code (NEC), state and local codes by a qualified electrician is also critical for efficiency and safety.

"Enhancing electrical safety and improving power quality and equipment operations are some key reasons for considering rewiring and upgrades."

-- Rural Energy Management Council (REMC)

Agricultural wiring also has some special requirements that may not be understood by all electricians. When hiring an electrician, look for someone who has taken a Farmstead Wiring course offered by the Wisconsin Technical Colleges to ensure he or she understands the code requirements for farms.

In most cases, rewiring or other electrical upgrades can also be done simultaneously when installing newer, more efficient motors, heating and cooling equipment, as well as lighting fixtures.

Rewiring is normally recommended regardless of equipment upgrades, especially considering the attractive program and incentive packages available from the utilities today that can help producers defray the project's costs.

Depending on the utility, grants ranging from $4,000 up to $10,000 and low interest loans are available along with different matching requirements for customers.

The farm rewiring programs offered by utilities are definitely helping to enhance the power quality on many farms. The program has also raised the bar for everybody in terms of following the National Electric Code standards.

With any new wiring system, it's important to keep at least four basic ideas in mind, according to the National Food and Energy Council:

- **Safety:** Fully complying with and adhering to National and State Electrical Codes are your best aids in developing a wiring system that will operate efficiently and safely for many years.
- **Adequately sized:** The wiring system must have enough circuits and outlets of the correct size and type and consist of the proper materials to prevent premature corrosion or overload. Also, give careful thought about what equipment, including the location and power demands, will be served by specific circuits and outlets. This information is also valuable when working with your utility to ensure that the transformer serving your farm is sized correctly.
- **Expandable:** Working with a qualified electrician and your utility on what things to consider for future additions or expansions can save a lot of headaches and unnecessary costs in the long run. This step becomes very important when specifying service entrance panels, sizing conductors, and selecting wiring methods.
- **Efficient:** A well-planned wiring system doesn't cut corners and allows sufficient planning time to work with your qualified electrician and/or utility. An efficient system minimizes power losses from voltage drops by using adequately sized conductors and uses quality components.

Spending the necessary upfront time to plan an efficient system is a wise investment that can generate significant dividends in terms of reliability and farm productivity.

"Conducting a thorough wiring checkup is recommended at least every two years, according to the Rural Energy Management Council (REMC)."

It's also important to underscore that deriving the safety and energy-saving benefits from today's more efficient equipment depends greatly on a well-designed and up-to-date wiring system.

In contrast, trying to operate new equipment with an undersized and grossly outdated wiring and component system can be very dangerous.

Editor's note: You're encouraged to contact your local utility and/or the Wisconsin Focus on Energy Program for more information on Farmstead

Rewiring programs. Specific contact information relating to rewiring program grants can be found in the appendix section of this handbook **(Appendix)**.

Equipment Operation and Maintenance

While a rewiring program can be extremely beneficial for a dairy operation, inspecting and maintaining the equipment served by the electrical system on a regular basis are also very important and will enhance your energy management efforts.

Refrigeration compressors, air-cooled condensers, refrigeration heat recovery units, pre-coolers, water heaters and vacuum pumps all play a critical role in dairy operations.

Choosing equipment based on efficiency along with good operation management and regular maintenance are important in reducing your energy bill. These factors can also offer the bonus of boosting your equipment's lifespan.

So, here are some key things to consider about equipment choices, operation and maintenance:

- Scroll Compressors / Reciprocating Compressors
- Milk Cooling / Refrigeration Heat Recovery / Pre-Coolers
- Water Heating
- Washing System
- Vacuum Pumps
- Livestock Water Fountains
- Ventilation and Fans
- Lighting Efficiently
- Electric Motors
- Fencers, Cow Trainers & Gates

CAUTION

Before attempting to do any cleaning, maintenance or inspections, make sure to read and review all safety precautions, including the operator's manual, that may have come with the electrical equipment. When in doubt about proper maintenance and/or cleaning procedures as well as safety measures, contact a qualified electrician or your utility representative.

Equipment Operation and Maintenance

Scroll Compressors

A scroll compressor is about 15 to 20% more efficient than reciprocating compressors that pressurized the refrigerant gas with a piston assembly. Scroll compressors have also been used very effectively in other industries for years with a proven and reliable track record.

Whether you are still using a reciprocating compressor or a scroll compressor, there are several maintenance factors to keep in mind.

"An unpublished study by the University of Wisconsin found a 3 to 5% reduction in energy use when the air-cooled condenser units are kept cleaned."

Have your refrigeration service provider check the refrigerant level and check for leaks annually.

The typical, air-cooled condenser units are used for expelling heat from the refrigerant to the air. Dust, lint, hair, grease and other debris can foul up these units and increase the energy consumption of the refrigeration system.

The units can be cleaned with a special degreaser specifically made for condensers. This special degreaser minimizes any affects to the aluminum and copper bonds in the condenser that transfer the heat to the air.

The degreasing solution is sprayed on, allowed to soak in and then rinsed off with low-pressure, warm water. Cleaning these units just twice yearly – taking only twenty or thirty minutes – could save you hundreds of dollars in energy costs, according to Sanford.

An unpublished study by the University of Wisconsin found a 3 to 5% reduction in energy use when the air-cooled condenser units are kept cleaned.

There are also a few other basic steps to follow that can help you reduce energy costs.

For example, it’s important to open up the vents to the outdoors and clean the condenser unit when the weather starts warming up in spring. Also, during the summer, condensers will operate more efficiently and cool better with access to outside air.

During the winter, the reject or waste heat can often be used to help warm the milk room.

Equipment Operation and Maintenance

Milk Cooling and Refrigeration Heat Recovery (RHR)

To help save energy for heating water, you can use a Refrigeration Heat Recovery (RHR) unit that captures heat from the system refrigerant, which would otherwise be discharged to the air, and transfers it to the water.

In short, the RHR preheats the water before it enters your water heater.

An RHR unit consists of a water storage tank and a heat exchanger. The heat exchanger can be separate from the water tank or jacketed to the outside of the storage tank and covered with insulation and a protective shell.

The popular jacketed storage tank, which is available in 50-, 80- and 120-gallon size tanks, transfers heat to the water as the hot refrigerant gas leaving the compressor unit is piped through the RHR heat exchanger jacket. The refrigerant inside the jacket is cooled, while the water in the tank is heated.

Depending on ambient conditions, the in-coming refrigerant gas to the RHR heat exchanger can reach more than 200° F. and then – before exiting the tank – drop to 115 to 125° F. as the heat transfers to the water.

“If your herd size is larger than 100 cows, a heat recovery unit tends to become more cost-effective than a pre-cooler,” says Sanford. “Smaller herd sizes don’t generate enough BTUs (British Thermal Units) from the milk to make using both units worth it.”

In most situations, the savings achieved in reducing energy demand for heating water will drive or influence part of the economic decision, according to Sanford, since “it’s more expensive to heat up the water than to cool down the milk – generally, you want to satisfy your water heating needs first.”

To maximize the recovery of waste heat, the general rule of thumb on sizing says the RHR storage unit should be large enough to provide all of the hot water needs for one milking. A large RHR tank may result in lower water temperatures that reduce potential savings on water heating.

The preventive maintenance on a refrigeration heat recovery unit would be similar to a hot water heater.

Sanford recommends draining out five gallons of water into a bucket at least a minimum of once a month to help minimize the buildup of calcium and other mineral deposits.

Another suggestion is to install a valve on the refrigeration heat recovery unit drain and use luke warm water on a daily basis for washing down the milk house or for other chores.

By doing this, you will consistently draw out water from the bottom of the RHR unit and, again, help reduce any sediment buildup.

Pre-coolers

How much do you spend monthly to cool your milk? On average, a dairy farmer spends about $75 a month on milk cooling, according to some utilities.

By installing a milk pre-cooler, you can save 20 percent to 30 percent – that's $15 to $20 every month.

A pre-cooler will cool milk with well water before it reaches the bulk tank to provide quick cooling and ensure the quality of the milk you produce. This pre-cooled milk reduces the demand on your bulk tank compressor—and that saves you money.

Simple to install and operate, the concept behind an inline pre-cooler is basic: warm milk is cooled down by well water. The pre-cooler is installed in the milk discharge line between the receiver and the bulk tank.

The milk in the pre-cooler (heat exchanger) flows one way while the water flows another – either through a series of tubes inside a shell or through a series of plates – with neither liquid coming in direct contact with each other.

If the pre-cooler is properly sized and an adequate supply of water is available, warm milk at 98° F. can be cooled down to about 58° F using an in-line pre-cooler – or to within at least 3° to 4° degrees of the well water temperature, according to Sanford.

"Overall, pre-coolers can decrease the cooling requirements by up to 65 percent," he says. "On the energy side, you will likely see a 15 to 30 percent savings on what your costs were prior to installing a pre-cooler."

A pre-cooler will operate better if you reduce dirt build-up inside by using a milk filter in the line during milking and washing. It's also a good idea to wash out the filter holder before replacing the filter after each milking and prior to the washing and cleaning cycle.

Make sure to turn off the well water supply to the pre-cooler during the wash cycle and drain the water from the pre-cooler prior to washing. Leaving the pre-cooler water supply on will only cool the wash water and reduce its effectiveness in cleaning.

Using the RHR With or Without a Precooler:

“Based on the efficiency savings of a heat recovery unit and pre-cooler, one can’t assume that the sum of the parts will be greater than the whole,” says Sanford. “Using these two pieces of equipment together won’t necessarily double your energy savings. That’s why an energy audit is important to determine just what choice or choices in equipment will make the best sense.”

Presently, using just a refrigeration heat recovery (RHR) unit on smaller dairy operations (i.e., 100 cows or less) tends to be the best option.

However, as you approach herd sizes of 150 or more, then using a heat recovery unit and pre-cooler in tandem starts to make the most economic sense. The economics is driven by the amount of hot water used and the pounds of milk cooled each milking and each day.

Bulk Tanks:

Due to the damp and wet conditions in the milk house, it’s important to check at least once or twice each year the condition of the wiring and connections to the agitator motor on the bulk tank. If in doubt, contacting your milk equipment dealer for an inspection is a good place to start.

Periodically inspecting any gaskets or seals on the top cover as well as on inlet and outlet pipes is also recommended.

It’s also important to check the timer to make sure that it will properly start and start the agitator motor as programmed.

Equipment Operation and Maintenance

Water Heater Replacement

A water heater may last 10 to 15 years with proper use and care. However, in case one needs replacement, it's a good idea to be prepared and to know your options.

There are three very basic things to consider when selecting a water heater:

- The first step is to decide what type of energy you want to use for heating water (i.e., electric, LP or natural gas, or oil) based on fuel pricing and efficiency.
- Second, you will need to determine the amount of hot water required over a specific time period.
- Third, you'll want to select a water heater with a high "Energy Factor" rating.

The Energy Factor (or overall efficiency factor) takes into account both water heating efficiency and standby losses.

The water heater tank should be insulated with a minimum of 2.5 inches or preferably 3 inches of foam insulation with a R-16 or higher value, according to Sanford. Fiberglass insulation is not recommended due to moisture and rodent problems.

The outer cover should be a non-corrosive material such as stainless steel or plastic, if it will be located in wash-down areas.

Heating water accounts for about 18% of the energy used on a dairy farm. How much water is used and the temperature to which the water is heated directly impacts the amount of energy used. **(3)**

Heating water above 165° F is not usually necessary and wastes energy. A properly adjusted wash system, which minimizes air admissions and uses a warm pre-rinse (100 - 110° F.), can wash the milking system effectively without using excessive high water temperatures.

It's also important to closely follow the manufacturers' recommendations on wash solution flow rates through the milking units for cleaning so that you don't waste water.

Tune Up Your Washing System

A basic way to minimize energy usage is to make sure that your washing systems – including clean-in-place systems – for the bulk tank and milking system are operating efficiently and properly. These two areas use a lot of water.

“Annually, have your dairy equipment dealer come in and tune up the clean-in-place washing systems for the bulk tank and milking system,” advises Sanford. “To save energy, it’s important to conserve the water and use only what’s absolutely required for flushing the system.”

A good example of a tune-up is to make sure the air injection system is working properly and check the settings to make sure you’re using only the amount of water needed for each wash cycle. In cold climates, wash-solution volume can often be reduced in the summer. However, remember to increase it in fall to assure enough thermal mass to maintain proper temperatures. **(4)**

Time, temperature, concentration, and physical action represent the chief factors in good cleaning procedures. **(5)**

For example, cleaning solutions need some time to work. In most farm equipment cleaning, about 10 minutes is adequate to dissolve or suspend milk solids.

Hot water is critical to emulsify milk fat, to disperse milk proteins, and to promote good cleaning action. For example, water for chlorinated alkaline detergent solutions must enter the wash sink at no less than 150°F, and it must be discharged to the drain at no less than 120° F. **(5)**

Generally, maintaining adequate cleaning solution temperature is more critical than the actual washing cycle duration. In short, washing for longer-than-recommended times doesn’t necessarily result in better cleaning. Consequently, it’s suggested to avoid circulating solutions until they cool below minimum recommended temperatures (120° F.), even if contact time of the cleaning solution is slightly shorter than recommended. **(5)**

Always use the recommended amounts of quality cleaners and sanitizers. Don't try to save money on bargain-priced cleaning chemicals, and carefully measure the amounts of water and cleaners you use.

Hard water can reduce the effectiveness of dairy cleaning chemicals. Most package labels will specify the amounts to use per quantity of water, according to the grains of water hardness.

Occasionally, the water hardness should be tested to determine what proper concentrations of cleaners to use and to decide whether or not installing a commercial water softener is necessary.

Even with a water softener, it’s also a good idea to drain a few gallons from the water heater monthly to reduce buildup of mineral deposits in the bottom of the tank.

Equipment Operation and Maintenance

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Equipment Operation and Maintenance

Vacuum Pumps

Since vacuum pumps consume, on the average, 17 to 20% of the dairy farm's electricity, this area is an obvious target in managing energy use.

In this case, you may want to consider using variable-speed vacuum pumps that can typically save 50 to 60% on electricity usage compared to regular, constant speed pumps.

A regular vacuum pump is inefficient because it's always running at a constant speed – regardless of how many milking units you use.

"Variable-speed vacuum pumps can typically save 50 to 60% on electricity usage compared to regular, constant speed pumps."

In the past, the normal industry standard for sizing vacuum pumps was as high as 10 cubic feet per minute (cfm) per milking unit, according to Sanford. Essentially, the regular vacuum pumps were oversized to meet a theoretical, maximum demand, such as during the start-up or fall-off stage.

However, research and experience have shown that the pump size can be reduced by at least half, in many cases.

For example, a University of Wisconsin study indicated that the average air consumption during milking is only about 2 cfm per milking unit.

Plus, thanks to computerization, a variable-speed drive pump can instantaneously change or modulate its speed – high or low – to match and maintain the necessary and optimum vacuum level required by the milking system.

A variable speed drive can be added to existing vacuum pumps, but blower type vacuum pumps work best, according to Sanford. Using a variable speed drive can be justified economically, if the vacuum pump is running more than 6 to 8 hours per day.

Maintaining the vacuum pumps in good working condition is important to the overall milking system performance. A faulty or poorly maintained vacuum pump may result in slower milking times and have an impact on udder health. **(6)**

The National Mastitis Council recommends a full test of the milking system at least yearly by the installer or an experienced technician who uses special measuring equipment and adheres to the standards established by the American Society of Agricultural and Biological Engineers (ASABE).

Equipment Operation and Maintenance

Livestock Water Fountains

According to the NEC, all electrically-heated livestock water fountains must have a grounding conductor from the service entrance to the water fountain to assure a low impedance (resistance) path and sufficient current flow to trip a circuit breaker or blow a fuse if an electrical fault occurs.

A grounding electrode may be installed at the water fountain for added protection, but it must be bonded to the equipment-grounding conductor. However, a grounding electrode is still not sufficient by itself.

Using a switch with a properly sized fuse adjacent to the water fountain offers convenience and additional safety. Installing a ground-fault circuit-interrupter (GFCI) device near the water fountain is also recommended for added safety and protection.

Electric heat tape is commonly used to prevent freezing of exposed water lines. To reduce the risk of electrocution, use only three-wire (third wire grounding) heat tapes.

If you're going to use livestock water fountains in cold climate conditions, then it's recommended to select frost-free or at least well-insulated models and to locate them in sheltered areas out of the wind.

Other recommendations include:

- Repairing or adding insulation as needed to the base cabinet and maintaining a seal around the base of the water fountain will reduce air infiltration and prevent freezing.
- Make sure covers or balls operate freely especially during periods of sub-zero temperatures.
- Use a thermostatically controlled heater and check thermostats monthly and adjust to just above freezing.
- Be sure to shut off electricity to water fountains when heating is no longer needed.

A poorly maintained water fountain can consume $200 or more in electricity per season, while a properly insulated and maintained unit will use $60 to $100 worth of electricity.

Equipment Operation and Maintenance

Ventilation and Fans

Box-type fans and large, low-speed paddle type fans – often called High Volume Low Speed (HVLS) fans – are the two principle types used for animal housing.

Box fans are used in conventional tie stall barns or loose housing such as free stall barns. The HVLS fans are recommended only for loose housing applications with high side wall heights.

If fans are being used, choose the most efficient ones available, and make sure they're equipped with totally enclosed motors (see section on Electric Motors). Generally, as fan diameters increase, the efficiency also goes up.

"Poor maintenance can reduce a fan's efficiency by 50% or more."

-- New York Cooperative Extension Service

For example, a standard 48" box fan would have an average efficiency of 17 cfm/watt, while a high efficiency 48" box fan would move 20 cfm/watt or more – a 20% increase in efficiency.

Generally, in dairy free-stall housing, the fans will be operating at 0 inches of static pressure, according to Kansas State University. In tie-stall or tunnel ventilated buildings, fans will be operating against 1/10 to 1/4 inches of static pressure.

To compare fans from different manufacturers, the Bioenvironmental and Structural Systems Lab (BESS) at the University of Illinois at Urbana-Champaign conducts standardized tests on fans with accessories and publishes the test results **(Appendix)**.

Selecting fans for energy efficiency – simply expressed as airflow rate per unit of input energy, or cfm per watt – is becoming very important. A higher cfm per watt rating will indicate a more efficient fan.

So, please remember that both fan performance and energy efficiency can vary widely. A 48" fan can have an efficiency as low as 13 cfm/watt or as high as 23 cfm/watt at 0.01" static water pressure for the same application. This is why it's recommended to review testing information from the BESS.

When comparing fans of different sizes or from different manufacturers, it's very useful to study their rated performance data and to find out if the evaluations have been tested under conditions similar to those in your facility. **(7)**

Any increased static pressure caused by operating conditions or accessories needs to be accounted for in ventilation system design. For example, if your fan will have shutters and a guard, then evaluate data where the fan was rated with shutters and guard in place.

This is important because outside shutters reduce airflow and efficiencies by 10 to 25 percent – a very significant loss and one reason why some may choose not to use them, if deemed appropriate.

With inlet-side shutters, you can expect a 10 to 15% airflow reduction, and discharge side shutters may result in a 15 to 25% reduction. **(7)**

Ventilation and Fan Maintenance Tips

Keeping a fan in good repair is as important in reducing energy costs as buying the most efficient model. Poor maintenance can reduce a fan's efficiency by 50 % or more. **(8)**

While High Volume Low Speed (HVLS) fans are normally recommended for loose housing applications, they may still be considered for modern and open free stall facilities. Photo: Midwest Rural Energy Council

- **Belt adjustment** is the single biggest maintenance problem with certain types of fans. Belt-driven fans must be regularly adjusted through the hot season for full air movement, so they should be easy to adjust.

- **Loose belts** can reduce airflow by as much as 30%. For existing fans, self-tightening devices can be retrofitted that will take up any slack as the belt stretches with use and age.

  When a new fan or a new belt has been installed, the belt should be readjusted after two weeks of operation to take up or compensate for the initial stretch.

- **Louvers** should shut tightly when a fan is not operating. If they don't, heat will escape, and the heater will have to run longer to make up for the loss. A single louver panel that will not close can waste up to $200 a year in fuel costs. Improperly working louvers can also reduce output by as much as 40%.

  When the fan is on, louvers must be fully open. Otherwise, they will restrict the flow of air from the building. A restricted fan operates longer

and bears a heavier load to achieve the desired amount of cooling, which costs more in electricity.

In many cases, you can repair louvers that are sticking (in the open or closed position) just by cleaning them and applying a dry graphite lubricant to the hinges. Graphite is recommended over oil because it will not attract dirt as rapidly and thus reduce the maintenance interval.

Any obstruction on the discharge of a fan impedes airflow. In short, fans with louvers on the outside are less efficient than comparable fans with louvers on the inside.

You may have to spend some time shopping to find fans with inside louvers since most fan louvers are built for installation on the discharge side.

Louvers also come in two basic types: motor-activated and air-activated.

Air-activated louvers reduce airflow 20% to 30% and are less efficient because fan power pushes the shutters open.

Motor-activated louvers eliminate that problem because the shutters lift and close automatically. In addition, motor-activated louvers will work even when dirty or when the joints get stiff, so cold air is less likely to enter during wintry days.

- **Safety guards** should be used on fans within reach of personnel to prevent accidents. The guard supplied by the manufacturer is usually best because it lowers fan airflow and efficiency very little (usually by less than 5%).

- **Installing thermostats** to control the fans' on-and-off operation saves energy and increases productivity.

  Research has indicated that dairy cows begin to show heat stress at 74° F with 70% relative humidity (the average relative humidity for Wisconsin), so it is recommended that the thermostat be set between 70° F and 75° F.

  Sanford recommends using a thermostat designed for outdoors in damp, dusty conditions. He suggests mounting the thermostats out of the reach of animals but in an area that will accurately reflect air temperatures around the livestock.

To ensure accurate readings, the thermostats need to be protected from direct sunlight and checked, cleaned and perhaps recalibrated monthly since dust can also affect accuracy.

Equipment Operation and Maintenance

Lighting Efficiently

As was mentioned earlier, lighting can account from 15% up to about 24% of electricity costs on a dairy farm. Learning how to use lighting effectively and efficiently not only can help trim your utility costs, but it can also improve working conditions and cow comfort.

Working conditions and cow comfort, as well as conserving energy, are greatly improved when lighting fixtures are used effectively and efficiently. -- Photo Karl Ohm

In a dairy, you are basically looking at three major characteristics in lighting-system performance:

Recommended Illumination Levels for Dairy Facility Chart

- **Light intensity or illumination level:** Illumination levels are measured with a light meter and expressed in foot-candles (fc).

  In a free-stall, for example, a typical and recommended illumination level would be an average of 15 fc, while a holding area can usually get by with 10 fc. As reference, a well-lit office usually has a light intensity of 35 to 50 foot candles.

  To help enhance a light's illumination, especially in outdoor yard lights, Sanford recommends retrofitting the light with a simple, snap-on full reflector that replaces the standard refractor.

  A refractor, which is a prism-type glass, only directs about 30% of the full lighting to where it's really needed.

Color characteristics: Just like sunlight with its various wavelengths that produce the different colors of a rainbow, artificial lights also produce their own distinct color spectrum that influence how well objects can be perceived by the human eye.

A commonly used rating is the Color Rendition Index (CRI), which ranges from 0 to 100 and indicates the light's ability to render the true color of an object. Lights with higher CRI values produce light that renders a truer color, while lower CRI values produce some color distortion.

Both the mercury vapor and high-pressure sodium lights have about the same color rendering index, according to Sanford, but the high-pressure sodium light is three times more efficient (measured as “lumens per watt”).

A lumen is a unit of measure of light output from a lamp. More specifically one lumen is equal to the amount of light emitted by one candle that falls on one square foot of surface located one foot away from one candle.

General Characteristics of Common Light Sources Chart

- **Uniformity of light:** The ratio of the fixture spacing to the mounting height determines the “uniformity” of light in a work area.

  Understanding this concept is important since mounting heights and the number of lights mounted in a given space impact the illumination recommended or required for critical areas in the facility.

  Also, it’s important to consider that the light reflectance in dairy barns usually ranges from 0 to 10% because of the dirty and dusty conditions.

  Typically, eliminating the use of incandescent bulbs and mercury vapor lamps is a successful way to increase lighting efficiency and reduce energy costs.

- **Fluorescents:** Fluorescent lights have ballasts that start up the bulbs. Electronic ballasts are recommended because they are more energy efficient, generate less heat, have a longer life expectancy, and operate and start at colder temperatures (0° F) than other ballasts.

  Magnetic ballasts are not recommended because they have operating and starting problems at temperatures of 50°F and below.

  Also, if existing fixtures are replaced, then upgrading to nonmetallic ones is recommended.

- **High Intensity Discharge Lights:** Metal halide, high-pressure sodium, and mercury vapor lights are part of a group of long lasting high intensity discharge (HID) lights that put out large amounts of lumens. They are used to light large areas.

  Metal halide lights put out a fairly white light with CRI values up to 80%. Their use in dairy facilities is growing.

  High-pressure sodium lights put out a gold or yellowish light with CRI values from 22 to 65% depending on the lamp type.

Lighting professionals in the field report that red is not clearly distinguishable from brown under low CRI high-pressure sodium lights. This means that bloody discharges may not be recognizable under high-pressure sodium lights.

Mercury vapor lights give off a bluish light and have been commonly used as yard lights; however, they are not recommended for dairy facilities because of low efficiency, and the CRI values range from 15 to 50%. The bottom line is that you have other and more efficient options than mercury vapor lights.

- **Compact fluorescents:** Compact fluorescent lights (CFL) can be used to replace incandescent lights when the existing fixture meets the National Electric Code safety requirements for livestock buildings. CFLs are not very tolerant of high moisture conditions and should be housed in a water resistant enclosure if used in a farm building. T8 Linear fluorescent lights provide the best life cycle cost option for new construction because of higher efficiency and longer bulb life.

  In the Recommended Illumination chart, you'll find a more detailed breakdown of suggested lighting levels for various areas in a dairy facility.

- **Keep Lights Clean:** It usually doesn't take too long before the normal airborne dust and dirt in dairy facilities begin clinging to lamp fixtures and robbing the original intensity of your lighting.

  Like a magnet, electrostatic forces within a light fixture are also at work in attracting those dirt particles and causing significant dirt build-up over time.

  "Typically, eliminating the use of incandescent bulbs and mercury vapor lamps is a successful way to increase lighting efficiency and reduce energy costs."

  There's a fancy term for this dirt build-up on lights, and some researchers are beginning to look at ways to put a number on it for dairy facilities. It's called Luminaire Dirt Depreciation (LDD). The impact of flies on lights is also being examined.

  While some light manufacturers have data on LDDs for residential, commercial, and industrial settings, no similar information exists for dairy facilities. Presently, designers must use data from these applications and try to match it as best as possible with the environment in dairy barns.

  Researchers at Cornell University and DL Tech, of New York, are doing field studies at dairy facilities to calculate the specific impact of dust, dirt and flies on light illumination.

Lighting systems for free-stall barns largely consist of using metal halide or high-pressure sodium, high-intensity discharge (HID) fixtures. These lamps don't "burn-out" like an incandescent bulb. Instead, the light output depreciates over time.

If a HID lamp is shutting down under power and restriking, this is a sign that the lamp is at the end of its useful life.

Based on industry information, the recommended relamping schedule for these fixtures is usually around every 4 - 5 years (the lights are generally lit only at night and sometimes not the entire night).

These lamps have an expected life of 20,000 - 24,000 hours, and if they're on for 12 hours daily (365 days per year), they should last 4 - 5 years.

Also, cleaning dirt and debris off these lamps about every six months is recommended to maintain good illumination.

- **Other basic maintenance points to consider are:**
  - Inspect sockets, hangers, reflectors and lenses for signs of corrosion, overheating and any physical damage that could potentially loosen electrical contacts or lead to moisture and dust collecting in the fixture.
  - Try to avoid intermittent or frequent on/off usage of fluorescent lamps – a procedure that will shorten lamp life and potentially damage the ballast.
  - When a fluorescent lamp blinks, the lamp should be replaced. If this does not solve the problem, then the ballast may need to be replaced. If that doesn't solve the problem, then you will need your utility or electrician with specialized tools to determine the problem source.

Recommended Illumination Levels for Dairy Facilities

Task	Intensity / Light level
Free stall	15-20 foot-candles
Tie stall barns - Feed alley	15-20
Tie stall barns - Center alley	20-50
General livestock housing	10
Holding area	10-20
Milking parlor - General	20
Milking parlor - Operator's pit	50 (at cow's udder)
Milk room	20
Manual wash sink	100
Vet / treatment area - General	20
Vet / treatment area - Treatment or surgery area	100
Utility room	20
Office area	50 (desk top)
Machine storage	10
Farm shop - general repair area	50
Exterior - security	0.5-1
Exterior - active areas	3-5
Loading & storage areas	20
Restroom	20
Source: Energy-Efficient Agricultural Lighting, A3784-14, 2004, Scott Sanford, Sr. Outreach Specialist, Univ. of Wisconsin's Rural Energy Program	

General Characteristics of Common Light Sources

Comparision of Lamp Types								
Lamp Type	**Lumens-Watt**	**Avg life (hrs)**	**Color**	**CRI**	**CCT (K)**	**Starting Temp (F)**	**Instant On**	**Wattage Range**
Incandescent	7-20	1,000	White	100	2800	> -40°F	Yes	25-200
Halogen	12-21	2-6,000	White	100	3000	> -40°F	Yes	45-500
Mercury Vapor	26-39	24,000	Bluish	15-50	3800-5700	-22°F	No*	50-1000
Compact Fluorescent	45-55	6,000 to 10,000	White	82	2700	32°F or 0°F	Yes*	14-29
T-12 HO Fluorescent	30-70	9,000 to 12,000	White	52-90	3000-5000	-20°F	Yes	25-110
Metal Halide	41-79	10,000-20,000	Bluish	65-70	3000-4300	-22°F	No*	150-1000
Pulse Start Metal Halide	60-74	15,000-32,000	Bluish	62-75	3200-4000	-40°F	No*	100-750
T-12 (1.5") Fluorescent	62-80	9,000 to 12,000	White	52-90	3000-5000	50°F	Yes	30-75
T-8 HO Fluoresecnt	81	18,000	White	75	3000-5000	-20°F	Yes	86
High Pressure Sodium	66-97	24,000	Yellow-orange	22-70	1900-2100	-40°F	No*	35-1000
T-8 (1.0") Fluorescent	76-100	15,000-20,000	White	60-86	3000-5000	50°F or 0°F	Yes	25-59
* Requires warm-up to reach full output.								
Source: Energy Conservation in Dairy Enterprises, March 2005, Scott Sanford, Sr. Outreach Specialist, Univ. of Wisconsin's Rural Energy Program								

Equipment Operation and Maintenance

Electric Motors

Electric motors available in a variety of sizes – from the very smallest to the largest – obviously play a dominant role on any dairy farm.

But like anything else that helps power your farm, they don't take care of themselves, and they can consume a lot of electricity unless, of course, you are using high-efficiency ones.

In fact, the purchase price for an electric motor is often very small compared to the electricity cost to operate the motor over its lifetime, especially when the motor operates more than one third of the time, and the cost of electricity exceeds $ 0.07 per kWh. **(9)**

This is one of the primary reasons why investments that you make today to improve your efficiency will yield returns throughout the life of the motor.

"Totally Enclosed Fan Cooled (TEFC) motors are designed to prevent moisture, dust and dirt from getting into the motor's windings and are required by code in Wisconsin."

Plus, such investments in efficiency will help soften the blow to the pocketbook if energy prices continue to increase.

So, when it becomes necessary to replace an electric motor, always consider making the extra investment in a high-efficiency motor (as compared to standard efficiency) because buying the cheapest motor may save you some money today, but it may end up costing you more during its life span.

When selecting motors, don't be penny wise and pound-foolish. It's always a good idea to avoid the cheap brands and, instead, consider upgrading to high efficiency units. In terms of life span, energy savings, and consistency in operation, they are very well worth it in the long run.

Totally Enclosed Motors – sometimes referred to as a Total Enclosed Fan Cooled motors – or TEFC – are well suited to dairy operations. These TEFC motors are designed to prevent moisture, dust and dirt from getting into the motor's windings and are required by code in Wisconsin.

The TEFC motors are considered essential for long life under the harsh operating conditions found on farms, according to the University of Nebraska – Lincoln (UNL), especially in feed processing and livestock housing areas.

In these conditions, permanent wiring for all fixed motors is required. Connecting fixed motors with plug and cord and where receptacles are likely to be left open frequently only invites trouble since the electrical system's integrity can be jeopardized. **(10)**

Using flexible cords (Type SE or SJE) or liquid-tight, flexible nonmetallic conduits are also recommend for movable equipment and equipment that vibrates during operation. Conductors with stranded wires are also recommended.

With outdoor equipment such as floating pumps or aerators, the UNL suggests that they be wired with Type STJEW, SEW or STEW flexible cord. Do not use submersible pump cable because sunlight (ultraviolet radiation) quickly destroys the insulation of such cables.

When a variable speed drive is used to power a motor, be sure that the motor is rated as “inverter duty” type. Inverter duty motors are designed specifically to work well and deliver long service lives when used with variable speed drives.

Motor Maintenance Tips

- Keep the motors in a clean place and properly size the motor for its intended use and/or application.
- Don’t use open motors on farms; the NEC requires Totally Enclosed motors.
- Inspect and clean accumulated dust off electric motors every month (or sooner if required) to keep them running cool and to prevent overheating.
- Check belt tension and alignment of all belt-driven equipment monthly. Belt slippage and misalignment of pulleys can shorten belt life by half. Always replace machine guards.
- Consider using cogged belts and pulleys on new equipment since they can reduce belt drive transmission losses. Losses of 5% are typical for standard V-belt drives.
- Use the proper size and type of motor for the application. Use totally enclosed motors for all farm applications.
- Install motors in a cool, clean, dry environment whenever possible.
- Install motors according to electrical safety codes and install all safety guards including belt guards with proper fasteners.
- Use a qualified electrician for proper motor installations and make sure the motor is selected and sized according to load factors recommended by the manufacturer.
- Use Variable Frequency Drives for varying loads such as milk pumps, vacuum pumps and ventilation fans. Again, use a qualified electrician for proper installation(s) and remember to use “inverter duty” motors with variable speed drives.

Equipment Operation and Maintenance

Fencers, Cow Trainers and Gates

Fencers, cow trainers, and crowd gates may not stand out as large energy consumers on dairy farms; however, if installed improperly or used incorrectly, problems like transient stray voltage can occur, according to the Midwest Rural Energy Council (MREC).

Crowd gates may not use much electricity; however, proper installation and maintenance help insure against possible transient stray voltage problems. -- Photo Karl Ohm

Again, conducting an energy audit plus assessing your present electrical system with a qualified electrician and/or your utility representative may uncover possible improvements to consider on how to maintain these devices. This will help promote efficient, safe operation and avoid future problems.

Examining the energizer circuits and connections – from the service panel to the energizer and then to the fencer – along with the location and installation of the earth return rod(s) and ground rod(s) represent some very important factors in a fencing system.

Checking the integrity of connections and wiring throughout the fence line and making sure that insulators are in good condition and free of obstructions can also improve efficiency and safety.

Paying attention to such factors becomes even more important because the system will be operated outside and in a range of weather conditions. This is why lightning protection remains a key component of a good fencing system.

The proper wiring and installation of cow trainers and crowd gates, which include electrical trainers, require special attention simply because high voltage pulses are flowing in and around a barn.

Voltage levels from the energizer, proper choices of wire insulation, installation of earth return rod(s) and ground rod(s), earth return and ground lead wires, location of the energizer relative to other metal or grounded objects, and the use of a surge arrestor are just a few factors that require some careful thought when using cow trainers and crowd gates.

Since this primer can't cover all the details, you are encouraged to turn to the appendix where you will find how to order an excellent publication, *Installation*

and Operation of Electric Fences, Cow Trainers and Crowd Gates, offered by the MREC.

This publication is also available online as a downloadable pdf file. In a question-and-answer format, the publication offers a comprehensive overview and numerous suggestions about this subject.

Appendix - Farm Electrical and Safety Checklist

Has an energy audit been conducted for your farm operation?

If not, then take the first step by contacting your local utility or the Wisconsin Focus on Energy Program to find out more about the benefits of a comprehensive energy audit.

Did a qualified electrician install your electrical system and follow National Electric Code for agricultural facilities?

Strictly following the NEC code and its practices will insure the efficiency and overall safety of your farm's electrical system. The NEC is the rulebook governing electrical wiring practices, and it's essential that your qualified electrician fully understands and follows these standards.

Does each building contain a single electrical service entrance?

This is necessary not only for better efficiency, but also more importantly for safely managing demand loads for a variety of situations and equipment needs. The service entrance panel must have a main service disconnect and should be surface mounted on a fire-resistant surface in a clean, dry room.

Are all electrical panels readily accessible and clearly labeled?

Avoid storing anything in front and within three feet of any electrical panel. Easy access to the panel is needed for maintenance and in emergencies. Every disconnect switch and circuit breaker must be clearly labeled.

Do all electrical cables and conduits enter boxes from the side or bottom?

This will minimize the dripping of condensation onto electrical contact surfaces and reduce corrosion.

Are all your "service entrance panels" to each of your buildings, including you home, properly grounded in accordance with the National Electrical Code (NEC) standards?

If you're not sure, then have a qualified electrician bring the panels up to NEC code for proper grounding to protect everyone, your animals and the electrical system from costly repairs, fires, stray voltage and possibly fatal accidents.

Are you visually inspecting your electrical system on a regular basis?

It's a simple step, but there's just no substitute for at least once a year performing a visual inspection of wiring and insulation. Keeping good records relating to trouble areas that need immediate attention by a qualified electrician is also recommended. Since inspection intervals are normally one year or more, comprehensive records are an important part of any maintenance program. Comprehensive records should be arranged to facilitate comparison from year to year.

Is the farmstead electrical system showing any signs of corrosion and other damage?

Line sags, loose supports, loose connections, corroded boxes, conduit or conductors, and damaged insulation greatly increase the risk of electrical system failure, fire, and electrocution of personnel or livestock.

Do you see any signs of discoloration or overheating in the electrical system and equipment?

Some major external conditions indicating overheating are: discoloration, cracking, flaking and scorching of outside finish of equipment, embrittlement of cable insulation, carbonization of material or finishes, and obviously any surfaces hot to the touch

Also, according to the National Fire Protection Assoc. (NFPA), fuse terminals and fuse clips should also be examined for discoloration caused by heat from poor contact or corrosion. Early detection of overheating is possible through the use of infrared examination. If evidence of overheating exists, the cause should be determined.

Are all lighting fixtures enclosed, dust-tight, watertight, made of corrosion-resistant material, and equipped with shatterproof covers or globes with proper gaskets?

With the harsh environment experienced on farms, the investment in such high-grade fixtures will offer better performance and reliability in the long run. Incandescent lighting fixtures must have a non-metallic, corrosion-resistant boxes and screwed-in-place gasketed globe covers. Fluorescent lights must have gasketed covers. All light fixtures must be designed to be watertight.

Are you using Ground Fault Circuit Interrupters (GFCI) on all outlets, especially outside or near water or high-moisture conditions?

A GFCI outlet is perhaps your best protection against lethal shocks and will greatly improve safety. If there is any leakage of current from the power leads, the GFCI will automatically cut the flow of electricity through the circuit, greatly reducing the severity of any shock. However, remember that GFCI's *don't* protect against accidental contact across the power leads.

Are circuit breakers frequently tripping and do you have unknown or dead circuits?

If this is happening, a qualified electrician should be called in to find the root cause(s).

Have you or a qualified electrician inspected bus bar and terminal connections on a yearly basis?

A bus bar is an electric conductor, often a metal bar inside a panel box that serves as a common connection for two or more circuits. A bus usually carries a large current. Any loose bus bar or terminal connection will cause

overheating that will lead to equipment malfunction or failure. Loose bonding or grounding can compromise safety and function.

Overheating in a bus or terminal connection will cause a discoloration in the bus bar, which can easily be spotted where connections are visible. By the time discoloration has occurred, there may have been enough damage to require replacement. So, it's better to check for loose connections regularly than to wait for discoloration or overheating to occur.

Are you regularly checking metal raceways?
Where a metal raceway is used as the equipment-grounding path, you should check couplings, bushings, set-screws, and locknuts to make sure they're tight and properly seated. Any metal raceway – used as the equipment-grounding path – should be examined carefully for rigid mounting and secure joints; screws and bolts should be retightened.

Are all grounding conductors electrically separated from neutral conductors, except in the main disconnect panel?
The equipment-grounding conductor is intended to carry current only in the event of an electrical fault.

Are all motors totally enclosed and rated for farm service and continuous operation? Are motors used with variable speed drives rated for inverter duty?
The improper use of motors increases the risk of premature motor failure, electrical shock and fire, according to the Illinois Fire Safety Alliance (IFSA).

Have you recently had a qualified electrician inspect the motor and wiring of your water well system?
Such inspection(s) will help reduce the likelihood of extraneous voltage problems from such a source.

Are you considering future expansions?
It's also important to keep in mind what changes in electrical service and/or components may be necessary that may result from expansion. Here, it's a good idea to discuss such plans with a "qualified" electrician and your electric utility.

Have family members and all hired workers been instructed on where and how to disconnect power in case of an electrical emergency?
Precious seconds or minutes can make a big difference when it comes to responding to such an emergency.

Do family members and all hired farm workers know first aid for electrical shock and/or burns?
If not, then contact your local hospital to find out how and where you can get

more detailed information, instructions or training on properly handling these situations.

Are your electrically heated livestock water fountains properly grounded?

Electrically heated livestock water fountains must have a grounding conductor from the service entrance to the water fountains to assure a low impedance (resistance) path and sufficient current flow to trip a circuit breaker or blow a fuse in the event of an electrical fault, according to the NEC.

A grounding electrode may be installed at the water fountain for added protection. However, a grounding electrode is not, by itself, sufficient. A switch with a properly sized fuse adjacent to the water fountain offers convenience and additional safety. Install a ground-fault circuit-interrupter (GFCI) device near the water fountain for added safety and protection.

Are all agricultural buildings equipped with a lightning protection system?

Only qualified electrical contractors, using materials listed with the Underwriters Laboratory (UL), should install a lightning protection system.

Appendix - Equipment Maintenance Checklist

Do you have a regular inspection and maintenance program for electrical equipment?

Outside motors, crowd gates, barn cleaners, feed-making equipment, plug-ins, electric tools, bulk tank motor, washing and drying machines, and even sump pumps and well motors are just a few examples of items that require attention to make sure they're operating properly and efficiently.

Have you recently reviewed installation/operating manuals for electrical equipment?

You may want to list (or make copies of) recommended, routine maintenance procedures and schedules and then link these items to a calendar. You can find the recommended items by gleaning from installation/operating manuals.

Do you have a recordkeeping system that organizes and tracks the preventative maintenance and repairs work on electrical equipment?

Keeping separate records of maintenance work performed (i.e., specific work done, parts and labor required, and other cost items) will, in the long run, help you uncover trouble spots and make decisions on preventive maintenance, future repairs and replacement of the equipment before it fails or burns out.

Do you have an organized recordkeeping or file system on equipment and/or parts suppliers that is easily accessible?

Taking the time to set up and organize a file system can reduce a lot of hassles if and when parts or replacement equipment must be ordered.

Do you have your fencers and cow trainers protected from lightning?

Locate electric fence chargers at least 10 feet away from buildings to reduce the risk of damage by lightning, according to Univ. of Nebraska-Lincoln. Do not connect the output ground terminal of any charging device to the electrical system. Also, follow NEC recommendations on where and how many lightning arrestors to install on fencers.

Appendix - Resource Information & Background

Wisconsin Focus on Energy
Phone: 1-800-762-7077
Web: www.focusonenergy.com
E-mail: aginfo@focusonenergy.com
Note: Click on “Where You Work” in left-hand column on home page, and then click on “agriculture.”

Also, the Focus on Energy program offers a web-based “Farm Assessment Toolkit” that was developed jointly with the Univ. of Wisconsin Extension. This toolkit can help identify areas for improving energy management and making informed choices in using efficient equipment. To get started, go to the following link: http://www.focusonenergy.com/page.jsp?pageId=8

Univ. of Wisconsin / Rural Energy Program
Scott A. Sanford
Senior Outreach Specialist
Agricultural Engineering Building
460 Henry Mall
Madison, WI 53706
Phone: 608-262-5062
Fax: 608-262-1228
E-mail: sasanford@wisc.edu

Rural Electric Power Services Program
Wis. Dept. of Agriculture, Trade & Consumer Protection
2811 Agriculture Drive / PO Box 8911
Madison, WI 53708 – 8911
Phone: 608-224-5055
Fax: 608-224-5110
Web: www.datcp.state.wi.us
Note: For web site, click on “Farming & Agriculture” in top heading, and then go to “Farm Center” heading.

UW Center for Dairy Profitability
University of Wisconsin - Madison
1675 Observatory Drive
266 Animal Science Building
Madison, WI 53706
Phone: 608-263-5665
Fax: 608-263-9412
Email: Dairyprofit@calshp.cals.wisc.edu
Web: www.cdp.wisc.edu/

Milking Research and Instruction Laboratory (UWMRIL)
The University of Wisconsin
Biological Systems Engineering Dept. Laboratory
540 Elm Drive
Madison, WI 53706
Web: www.uwex.edu/uwmril/index.html

Energy Center of Wisconsin
455 Science Drive, Suite 200
Madison, WI 53711
Web: http://www.ecw.org

Appendix - Associations & Organizations

Midwest Rural Energy Council
460 Henry Mall
University of Wisconsin-Madison
Madison, WI 53706
Phone: 608-262-1228 (fax)
E-mail: mrec@uwex.edu
Web: www.mrec.org

Wisconsin Electric Cooperative Assoc.
131 West Wilson Street Suite 400
Madison, WI 53703
Phone: 608-258-4400
Fax: 608-258-4407
Web: www.weca.coop/index.html

National Food and Energy Council
P.O. Box 309
2333 Rombach Ave.
Wilmington, OH 45177
Phone: 937-383-0001
Fax: 937-383-0003
E-mail: info@nfec.org
Web: www.nfec.org/

National Electrical Manufacturers Assoc. (NEMA)
1300 North 17th Street / Suite 1847
Rosslyn, VA 22209
Phone: 703-841-3200
Fax: 703-841-5900
Web: www.nema.org

National Fire Protection Assoc. (NFPA)
1 Batterymarch Park
Quincy, MA 02169-7471
Phone: 1-800-344-3555
Fax: 617-770-0700
Web: www.nfpa.org

National Rural Electric Cooperative Assn. (NRECA)
4301 Wilson Blvd.
Arlington, VA 22203
Phone: 703-907-5500
E-mail: nreca@nreca.coop
Web: www.nreca.org

Note: The NRECA is the national service organization representing the national interests of cooperative electric utilities and the consumers they serve.

Consortium for Energy Efficiency, Inc. (CEE)

98 North Washington St. / Suite 101
Boston MA 02114-1918
Phone: 617-589-3949
Fax: 617-589-3948
Web: www.cee1.org
Note: CEE is a national, nonprofit organization that promotes energy-efficient products and services.

American Council for an Energy-Efficient Economy (ACEEE)

1001 Connecticut Avenue, NW Suite 801
Washington, DC 20036
Phone: 202-429-8873
Fax: 202-429-2248
E-mail: info@aceee.org
Web: www.aceee.org
Note: The ACEEE is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection.

National Mastitis Council (NMC)

421 S. Nine Mound Rd.
Verona, WI 53953 USA
Phone: (608) 848-4615
Fax: (608) 848-4671
Web: http://www.nmconline.org/
Note: Web site contains information and links relating to milking systems.

Appendix - Web Sites

Wisconsin Focus on Energy / Dairy

Web: www.uwex.edu/energy/dairy.html
Note: This site contains specific links to various dairy energy related topics.

Stray Voltage information

(University of Wisconsin Milking Research and Instruction Laboratory)
available at web: http://www.uwex.edu/uwmril/stray_voltage/svmain.htm

Univ. of Wisconsin Energy Efficiency and Renewable Energy Resource Site

Contain information and link on energy efficiency in agriculture, wind, solar, methane digesters, residential energy efficiency and more.
http://www.uwex.edu/energy/

Appendix - Contacts for Rewiring Programs

Alliant Energy
Web: www.alliantenergy.com/
Note: Click on top heading, “Utility Services,” and then click on “Farm.”

Wisconsin Public Service
http://www.wisconsinpublicservice.com/farm/farm_rewiring.asp

Wisconsin Electric Cooperative Association
http://www.weca.coop/we/safetyfirstfp.htm

Xcel Energy
http://www.xcelenergy.com/
Note: Click on “Business” at top heading and go to “Program & Resources” and then select and type in zip code that most closely matches your service location (i.e., 54701 for Eau Claire). The topic/link, “Farm Rewiring”, appears in the left-hand column of web page.

WE Energies
http://www.we-energies.com/agricultureservices/index.htm

Appendix - Publications

University of Wisconsin – Cooperative Extension Service Publications
(https://cecommerce.uwex.edu/)

Go to upper, left-hand column and click on “Agriculture” and then go to “Energy, Engineering, Environment, Safety” heading. This will take you link you a page full of energy and equipment related publications and fact sheets which are available as hard copies (for a modest fee) or as pdf files.

Low-Cost Energy Conservation: General Farm Enterprise (A3784-9), Scott Sanford, Univ. of Wisconsin Extension, 2003.
Available as pdf file at: http://cecommerce.uwex.edu/pdfs/A3784-9.pdf

Ventilation and Cooling Systems for Animal Housing (A3784-6), Scott Sanford, Univ. of Wisconsin Extension, 2004.
Available as pdf file at: http://cecommerce.uwex.edu/pdfs/A3784-6.pdf

Heating Water on Dairy Farms (A3784-2), Scott Sanford, Univ. of Wisconsin Extension, 2003.
Available as pdf file at: http://cecommerce.uwex.edu/pdfs/A3784-2.pdf

Maintenance of Milking and Milk Handling Equipment, Ontario Ministry of Agriculture, Food and Rural Affairs.
Fact Sheet available at:
http://www.omafra.gov.on.ca/english/livestock/dairy/facts/85-001.htm

Long-day Lighting in Dairy Barns, University of Wisconsin – Madison.
Available at web: http://www.bse.wisc.edu/hfhp/tipsheets_html/lighting.htm

Lighting Dairy Facilities, University of Minnesota, Updated 2002.
Available at web: www.bae.umn.edu/extens/ennotes/ensum99/lighting.html

Dairy Lighting System for Free-stall Barns and Milking Centers, updated 2004.
Available at web: www.bae.umn.edu/extens/aeu/aeu12.html

Agricultural Ventilation Fans, Performance and Efficiencies, published by the BESS Lab, Univ. of Illinois, offers an unbiased source of performance data for more than 300 commercially available ventilation fans.
Ordering information is available at:
www.age.uiuc.edu/bee/Research/handbook/handbook.html

Fan Selection and Maintenance, Kansas State University, March 2001, EP 75.
Available as pdf file at: www.oznet.ksu.edu/library/lvstk2/ep75.pdf

Selecting Rated Ventilation Fans (G 85), Pennsylvania State Agricultural and Biological Engineering, 1996.
Available as pdf file at: www.age.psu.edu/extension/factsheets/g/G85.pdf

Wisconsin Electrical Dairy Equipment Survey Results, May 2005, provides a very updated and condensed overview of opinions from numerous dairy operations about stray voltage matters and the use of electrical equipment.
The survey is available as a pdf file at:
www.nass.usda.gov/wi/dairy/dy_elect_equip.pdf

Stray Voltage and Electrical Safety Problems Go Hand-in-Hand:
Published by University of Minnesota, updated 2004.
A vailable on web at: http://www.bae.umn.edu/extens/aeu/aeu2.html

Installation and Operation Of Electric Fences, Cow Trainers and Crowd Gates - A Self-Help Guide: Published by the Midwest Rural Energy Council (MREC).
Complete guide is available as pdf on line at:
http://www.mrec.org/Stray_Voltage/ElectricFencers_MREC_05.pdf

Farm Rewiring Program Bulletin, published by Wis. Dept. of Agriculture, Trade & Consumer Protection.
A vailable as pdf file at: www.datcp.state.wi.us/mktg/agriculture/farm-center/pdf/farm_rewiring_newsletter.pdf

Agricultural Wiring Handbook, 13th Edition, 2002, published by the National Food and Energy Council, P.O. Box 309, 2333 Rombach Ave., Wilmington, OH 45177. Phone: (937) 383-0001 Fax: (937) 383-0003 Web: www.nfec.org

Electrical Systems for Agricultural Buildings (Recommended Practices), published by the University of Nebraska – Lincoln, (Bulletin No. G87-845-A, Revised January 1993). This describes some of the specialized wiring practices and equipment required in agricultural buildings. Presently, this publication is not available on line; however, you may contact the following to see if it's available in hard copy form: UNL Publications Warehouse, P.O. Box 830918, Lincoln, NE 68583-0918.

The Midwest Plan Service (MWPS): The MWPS is a university-based publishing cooperative dedicated to publishing and disseminating research-based, peer-reviewed, practical, and affordable publications that support the outreach missions of the 12 North Central Region land-grant universities plus the U.S. Department of Agriculture (USDA). Address: 122 Davidson Hall, Iowa State University, Ames, IA 50011-3080. Web site: www.mwpshq.org. Phone: 1-800-562-3618 or 1-515-294-4337 Fax: 1-515-294-9589 E-mail: mwps@iastate.edu

Wiring Handbook for Rural Facilities, MWPS-28 (replaces Farm Buildings Wiring Handbook, Second Edition) – Based on the National Fire Protection Association (NFPA) 70-1990 National Electrical Code® (NEC), this handbook shows and explains materials and methods for assessing and installing electrical wiring in equipment and farm buildings. Standby power, alarm systems, stray voltage, and lightning protection also are considered.

https://www.mwpshq.org/construc.htm#anchor_mwps28

Appendix - Glossary of Terms

Ampere: The measurement of the flow of an electric current through a conductor.

Btu: The British Thermal Unit (Btu) is a precise measurement of energy. It is the amount of energy required to raise the temperature of one pound of water one degree Fahrenheit when the water is near 39.2 degrees Fahrenheit.

Circuit: A complete path over which an electric current can flow.

Color Rendition Index: A measure of light quality. The maximum Color Rendition Index (CRI) value of 100 is given to natural daylight and incandescent lighting. The closer a lamp's CRI rating is to 100, the better its ability to show true colors to the human eye.

Conductor: An electrical path that offers comparatively little resistance. A wire or combination of wires not insulated from one another, suitable for carrying a single electric current. Bus bars are also conductors.

Correlated Color Temperature – or CCT (K): A specification of the color appearance of a lamp relating its color to that of a reference source heated to a particular temperature, measured in degrees Kelvin (K). Generally, CCT measures the "warmth" or "coolness" of the light source appearance.

Current: The movement of electrons through a conductor (measured in amperes, milliamperes, and microamperes).

Foot-candle: A foot-candle (fc) is a unit of measure of the intensity of light falling on a surface, equal to one lumen per square foot of surface.

Kilowatt-hour: The kilowatt-hour (or kWh) is a unit of energy equivalent to one kilowatt (one thousand watts) of power used continuously for one hour of time.

Lumen: A lumen is a measurement of light output: One lumen is equal to the amount of light emitted by one candle that falls on one square foot of surface located one foot away from one candle.

Ohm: The unit of electrical resistance. Resistance is one ohm when a direct current (DC) voltage of one volt will send a current of one ampere through.

Relative humidity: The ratio of water vapor contained in the air compared to the maximum amount of moisture that the air can hold at that particular temperature and pressure.

Volt: A basic measurement of electrical pressure or force in a circuit. Volts x amps = watts.

Watt: The standard unit of measurement of electrical power. One watt is one ampere of current flowing at one volt.

References

1. Kansas State University (KSU)
2. Energy Center of Wisconsin, Energy Efficiency and Customer-Sited Renewable Energy, ECW Report Number 235-2, Oct. 2005
3. Scott Sanford, Univ. of Wisconsin Extension
4. Univ. of New Hampshire Cooperative Extension (2002)
5. Oregon State University (OSU)
6. Animal Production and Health Paper 78, Food & Agriculture Organization
7. Pennsylvania State University's (PSU) Agriculture and Biological Engineering Dept.
8. New York State Cooperative Extension Service
9. Pennsylvania State University (PSU)
10. University of Nebraska - Lincoln