# ENERGY CONSERVATION FOR FARM COOPERATIVES

Scott Sanford [1]

There are many things that can be done to reduce electrical and gas costs at farm cooperatives. They can be as simple and low cost as changing a light bulb or may require upgrading or replacing a grain dryer to reduce energy costs by thousands of dollars per year. The annual operating cost needs to be calculated for each energy-saving option under consideration because a lower initial cost is seldom an indication of annual cost of ownership and operation. The paper briefly looks at lighting technologies, space heating, grain drying, grain handling and electric motors in terms of energy efficiency.

## Lighting

There have been many new advances in lighting technologies in recent years. Compact fluorescent lamps (CFL), T-8 linear Fluorescent lamps and Pulse-Start Metal Halide lamps are a few of those technologies.

Compact fluorescent lamps have existed for many years but recent advances have solved many of the issues of earlier versions. They are design to be a direct replacement for incandescent bulbs, providing the same illumination while using only 25% of the electricity. The expected life of a CFL is also considerably longer, lasting 6,000 to 10,000 hours versus an average of 750 to 1000 hours for the typical 100 watt incandescent bulb. This results in lower maintenance costs. Fluorescent lamps are know for not working well in cold temperatures but CFL have been engineered to work down as low as - 20°F. They do require a few minute to warm up in cold weather but once warm will provide almost full rated output. If used in moist, corrosive or dusty environments, the lamps should be housed in a protective sealed fixture. When purchasing compact fluorescent lamps for use in enclosed fixtures, look for a rating on the packaging that the lamps are design for use in enclosed fixtures or purchase lamps with 10,000 hour life ratings for best results. If a CFL in an enclosed fixture starts to flicker, that's an indication the ballasted has overheated.

T-12 linear fluorescent lamps (1-1/2" in diameter) have been used widely for many years because of their higher efficiency than incandescent lamps but are now being replaced by the newer T-8 linear fluorescent lamps (1" diameter). T-8 lamps are 20% more energy efficiency than T-12 lamps and last 65% longer, lowering operating and maintenance costs. They use electronic ballasts (versus electromagnetic ballast) which allow the lamps to work at temperatures down to 0°F with no flickering which is a fault of T-12 lamps. There is a high output (HO) T-8 version that will work down to -20°F which makes them suitable for cold areas where an instant on light is needed. The T-12 and T-8 lamps are the same length and use the same sockets so an existing fixture (provided it is in good condition) can be retrofitted by replacing the ballast and lamps. Manufacturers have introduced 48-inch 6-lamp sealed fixtures that can be used in damp, dusty condition that are intended to replace metal halide lamps. T-8 fluorescent lamps are about 35% more energy efficient than metal halide lamps and provide about the same lamp life.

Mercury vapor, metal halide and high pressure sodium lamps are all in a class of lamps called high intensity discharge (HID) lamps. Mercury vapor lamps are the least energy efficiency of the three types and have high lumen depreciation, losing half of their light output every 5 years. They never really burn out, just fade away. For outdoor or indoor lighting with high ceiling

[1] Senior Outreach Specialist, Biological Systems Engineering, Univ. of Wisconsin, Madison, WI.

heights (greater than 12 feet) high pressure sodium (HPS) lamps are recommended. These high efficiency lamps emit a yellow / orange light and are 150% more efficient than a mercury vapor lamp. A mercury vapor would require 2.5 watts to produce the same amount of light as 1 watt would produce in a HPS lamp. If color recognition is require, then pulse-start metal halide lamps would be recommended as it emits a white light and has a high color rendering index (the ability of humans to perceive colors under different lights compared to sun light – 100% equals sunlight). Pulse-start metal halide lamps are a newer version of a metal halide lamp that starts faster, is about 10% more efficient, has 50% longer life and less lamp depreciation (loss of light output as the lamp ages). Lamp types and ballasts can not be mixed therefore changing a lamp type will require changing the entire fixture.

Table 1 lists the lamp types use in agricultural in order of energy efficiency as determined by the light output, measured in lumens, divided by the energy input, measured in watts (lumens/watt). Other information in the table includes average lamp life, color of light emitted, Color Rendering Index (CRI) which is a measure of how well humans can perceive colors illuminated by a particular lamp type, Correlated Color Temperature index (CCT) which is a description of the color appearance in degrees Kelvin, minimum starting temperature, and whether the lamp proves light instantly or requires a warm-up period. The table should be helpful in selecting new or replacement lamps.

Table 1: Comparison of lamp types (Data adapted from manufacturer's literature)

| Lamp type | Lumens/watt @mean lumens | Average life (hr) | Color | CRI | CCT (K) | Starting temp. (F) | Instant on |
|---|---|---|---|---|---|---|---|
| Incandescent | 7-20 | 1000 | White | 100 | 2800 | > -40°F | Yes |
| Halogen | 12-21 | 2-6000 | White | 100 | 3000 | > -40°F | Yes |
| Mercury Vapor | 26-39 | 24,000 | Blue-Green | 15-50 | 3800-5700 | -22°F | No |
| Compact Fluorescent | 45-55 | 6000 to 10,000 | White | 82 | 2700 | 32°F or 0°F | Yes * |
| Metal Halide | 41-79 | 10,000 - 20,000 | White | 65-70 | 3000-4300 | -22°F | No |
| Pulse Start Metal Halide | 60-74 | 15,000 - 30,000 | White | 62-75 | 3200-4000 | -40°F | No |
| T-12 Fluorescent | 62-80 | 9000 to 12,000 | White | 52-90 | 3000-5000 | 50°F | Yes |
| T-12 High Output Fluorescent | 30-70 | 9000 to 12,000 | White | 52-90 | 3000-5000 | -20°F | Yes |
| T-8 High Output Fluorescent | 81 | 18,000 | white | 75 | 3000-5000 | -20°F | Yes |
| High Pressure Sodium | 66-97 | 24,000 | Yellow-orange | 22 - 70 | 1900-2100 | -40°F | No |
| T-8 Fluorescent | 76-100 | 15,000 - 20,000 | white | 60-86 | 3000-5000 | 50°F or 0°F | Yes |

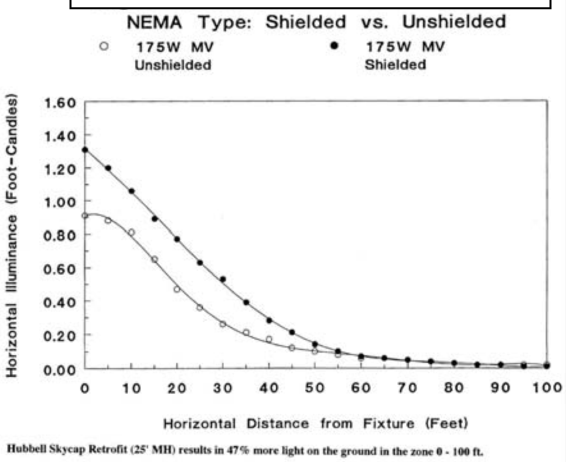
* Requires warm-up to reach full output

## Outdoor Lighting

Photo 1 – Full Cut-off Reflector

The old standby lamp for outdoor lighting is a 175-watt mercury vapor lamp in a fixture that is designed to be mounted on a pole and is often called a pole or yard light. It has a diffuser/refractor that allows the light to be emitted in almost all directions. About 30% of the will travel above horizontal and is lost to the sky. A full cut-off reflector can be fitted to most yard light fixture to reflect the light to the ground were it is desired. Figure 1 is a graph of the light levels at the ground for a 175 watt mercury vapor lamp. The difference in light level between the curves represents 47% more light at the ground. If the 175 watt lamp provided adequate light without the full cut-off reflector, then a 70 watt or 100 watt high pressure sodium light with a full cut-off reflector will provide more light at about half the cost. The full cut-off reflectors can be retrofitted to most existing fixture for $30 to $45 depending on brand. There are three manufacturers of the full cut-off reflectors to fit yard lights, General Electric – Sky Guard, Hubbell – SkyCap and RAB Manufacturing – Down Blaster.

Figure 1 – Shielded light distribution




## Is Lighting Needed All Night?

If not, lights can be controlled with clock timers or for yard lights there is a "Half-Night" photo sensor available that measures the night length daily and turns the light off the second half of the night saving half the electrical cost. Half-night photo sensor is manufactured by Thomas and Betts Corp (DPN124 2.6) and can be ordered through electrical equipment suppliers.

Outdoor lighting is often installed for "security" reasons but if ***no one is watching the hen house*** is there really security? However, if a photo/motion sensor is used to control lighting and the light turns on, it is more likely to be noticed or to discourage intruders than if the light is on continuously. Multiple motion sensors and lights can be installed to cover large areas if needed.

## Lamp Disposal

All of the lighting technologies available today contain some amount of mercury vapor except for incandescent and halogen bulbs. This includes compact fluorescent lamps (CFL), linear fluorescent lamps (all types), mercury vapor, metal halide, high pressure sodium lamps and low pressure sodium lamps. Wisconsin state law requires all businesses to recycle mercury containing lamps or to dispose of them as hazardous waste. Companies that do not recycle their waste lamps may be considered hazardous waste generators and subject to hazardous waste rules. Recycling is much cheaper and helps in protecting our environment. Companies that recycle lamps recover the mercury, smelt the metals and recycle the glass resulting in a win-win situation. Some lamps are TCLP (toxicity characteristic leaching procedure) compliant which means they contain lower amounts of mercury but they still contain mercury and should be recycled.

## Space Heating

Since 1992, manufacturers of furnaces have had to manufacture furnaces with minimum Annual Fuel Utilization Efficiency (AFUE) ratings of 78% or higher. Today there are two classes of furnaces: high efficiency and mid-efficiency. The high efficiency in a gas furnace are 90% or higher efficiency while oil fueled furnaces are 80% or higher. High efficiency furnaces are available for forced air heating or hot water / hydronic systems. These types of heating systems are best for office or retail space. These new furnaces are generally low maintenance but that doesn't mean maintenance is not needed. Annual maintenance is highly recommended to replace filters, tighten belts, and check burners.

For large retail spaces, warehouses, or areas with high ceilings, low intensity radiant heating systems can reduce energy costs while still providing a comfortable environment. Radiant heating heats the objects under the heaters and not the air directly. They offer quick warm up and the ability to heat localized areas and not the entire space which saves energy.

## Grain Drying

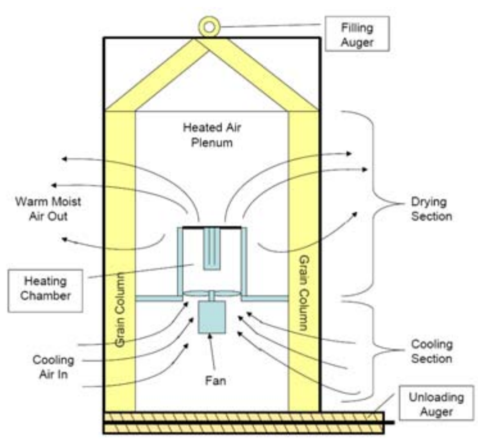
The energy efficiency rating of grain dryers is measured as BTU per pound of water removed. Efficiency ratings will vary by grain type (corn, wheat, soybeans). There are not any unified test standards for rating grain dryers in North America so manufacturer's ratings may not always be comparable. There is some limited independent test data for dryers and limited research data to use for comparisons. A general rule of thumb for energy usage in a high temperature dryer is 0.02 gallons of LP gas or 0.018 Therms of natural gas per bushel per % point moisture removed and 0.01 kWh of electricity per bushel per % point moisture removed.

The first step to reducing energy costs is to only dry clean grain. It is recommended that grain be screened before and after drying to remove chaff, weed seeds, bees wings, and broken kernels. This will increase air flow in dryer, reduce plugging of screens and aeration floors and dry only salable product.

### Cross-Flow Dryers

Cross-flow dryers are very popular but are not an efficient dryer unless heat recovery is included. Heat can be scavenged from the grain being cooled in the dryer or from the lower drying section to reduce energy costs by 10 to 20%. Existing dryers can be retrofitted with ductwork to capture and recycle scavenged heat for intake air to the heating section. Many new dryers use reverse flow or suction cooling where all or a portion of the air for the heated section is drawn through the cooling section. The air enters the dryer by passing through the column of corn in the cooling section, picking up heat from the corn as it cools and then passes through the fan and burner into the heating section plenum, see Figure 2. Reverse flow cooling is available on horizontal or tower dryers.

Figure 2:
Reverse Flow Cooling



Mixed Flow Dryers

Mixed flow dryers are a high efficiency column type dryer that does not have screens and can therefore dry grains from rape seed to corn. They are 20 to 40% more efficient than the typical cross-flow dryer, using a con-current and counter flow air pattern to dry the grain. The retention time for mixed flow dryers is typically twice as much as a cross-flow dryer and is sited for less variation of kernel moisture and higher starch utilization (up to 10%). These dryers are available with multiple heating zones if needed. The mixed-flow dryers may cost a little more than a cross-flow dryer but have lower energy costs. The analysis of a 900 bushel/hour cross-flow dryer compared to a mixed flow dryer indicated a 1 to 2 year payback on the additional investment based on energy savings only. Mixed-flow dryers are available in capacities from 250 to 4600 bushels per hour for 10 points of moisture reduction in corn. The one disadvantage of mixed-flow dryers is a larger footprint requirement as compared to a tower type cross-flow dryer. There are four companies that sell mixed-flow type dryers in North America, see Table 2.

Table 2 – Mixed flow dryer manufacturers.

| | | |
|---|---|---|
| Grain Handler USA, Inc, | Minneapolis, MN; | 612-722-1085 |
| NECO (Nebraska Engineering Co.), | Omaha, NE; | 1-800-367-6208 |
| Phoenix Rotary Equipment, Ltd., | Nisku, Alberta; | 1-888-891-9929 |
| Cimbria Bratney Co., | Des Moines, IA: | 1-800-247-6755 |

Continuous In-Bin Dryer

Continuous in-bin dryers are basically automated bin dryers that have control systems to automatically sense the grain moisture and divert the grain to a storage bin as it dries. This dryer type is 25 to 40% more efficient than cross-flow dryers. The continuous in-bin dryer system can be installed in an existing grain bin with a full aeration floor or in a new bin. The control system sensors monitor the grain moisture at the bottom of the bin and when the grain is dry, a sweep auger takes a sweep around the bin floor to remove the dried grain. Grain is transferred to a storage or dryeration bin hot where it is cooled. With this system the wet grain is piled on top of the drying grain which eliminates the need for a wet bin and the associated grain handling to transfer wet grain. The drying capacity of continuous in-bin drying systems ranges from 8000 to 17,000 bushels per day (330 to 700 bu/hr) which limits their feasible to small cooperatives. Aside from size limitations, continuous in-bin dryers will accumulate fines on the aeration floor and typically will require shutting down and emptying out every 3 to 5 days to remove the fines. An advantage of this type of dryer is that it can be used for storage at the end of the drying season by running the dryer as a re-circulating dryer for the last batch. Several companies can install the automated systems to convert a batch bin dryer to a continuous dryer.

In-Bin Cooling

The procedure for in-bin cooling is to transfer the grain hot at a moisture level 1 to 1.5% points above the desired storage moisture level to the storage bin. Cooling fans are turned on as soon as filling starts and run until the grain is within 5 to 10°F of ambient air temperature. Typically 0.2% points of moisture can be removed from corn per 10°F of temperature reduction during cooling. A 10 to 15% savings in fuel costs can be expected along with an increase in dryer capacity of up to 33%.

Dryeration

Dryeration offers three advantages: energy savings, an increase in dryer capacity of up to 70% and an increase in grain quality. The dryeration process involves transferring the corn hot to a bin with aeration at 2 to 3% points of moisture above storage moisture level, allows the corn to steep without aeration for 4 to 12 hours and then cooled before transferring it to storage. Grain should not be stored in the dryeration bin because moisture will condense on the bin walls causing pockets of wet grain that will spoil if not moved. The steeping process allows the moisture remaining in the kernel to equalize before cooling. This reduces seed coat stress cracks by 36% and kernel breakage by 5% according to one university study compared to rapid cooling. For continuous operations, multiple steeping bins will be needed so while one bin is steeping, another bin is being filled. The energy savings from this process can be up to 25%.

Dryer Maintenance

Maintenance before and during the drying season is very important for optimal efficiency of a dryer. Before the fall drying season, belts should be checked and tightened, check burner for proper operation (blue flame), clean fan housings, tighten and lubricate bearings, make sure all guards are in place, check electrical controls and switches, and calibrate thermostats and sensors. During drying operations, screens need to be check and cleaned daily, spot check plenum temperatures and check grain handling equipment.

Grain Handling

Although grain handling is not as expensive as drying, anytime we can use gravity to move a product, costs are reduced. For tall bins using a Side Discharge chute will reduce handling costs and may increase handling capacity, see Photo 2. A side discharge is a pipe that extends into a bin through the side wall to the center of the bin. It is important that the pipe extend to the center of the bin so that the forces the grain exerts on the bin walls remain uniform as the grain is removed. If the grain is unloaded from the side instead of the center, the forces on the bin side walls will not be uniform and could lead to structural failure. A gate on the side discharge is used to control the grain flow.

Photo 2 – Side Discharge Chute

## Motors

There are many motors used in the grain handling process: fans, augers, grain legs, etc. The Department of Energy estimates that motors consume 50% of all electricity in the U.S. and accounts for 84% of electricity used in agricultural production or electric motors consume $84 of every $100 of a cooperatives electric bill. Over the lifetime of a motor, the cost of energy to operate the motor is approximately 95% of its original cost. Choosing an energy efficient motor will pay dividends especially on high horsepower motors and motors that run many hours per year. Too often motor decisions are made at the time of a failure when the clock is ticking and downtime costs are escalating. Motor Matters is a program developed by Washington State University for the US Department of Energy, recommends inventorying your motors and running a cost analysis to determine what the best option is when and if a motor fails. Those options may include re-winding the motor, replacing it with a standard motor or replacing it with a high efficiency motor. It is also recommended that sources for re-winding services or new motors be researched ahead of time so when a motor needs to be replaced or re-wound, the planned decision can be implemented. This many require negotiations with your motor supplier to stock motors and motor parts required for critical operations or having motors on inventory at the cooperative. There is software available to aid in setting up a planned motor replacement program from the U.S. Department of Energy. Refer to the reference list for information on where to find the MotorMaster+ software.

There are three classes of 3-phase motors available. A "standard motor" is a three-phase motor made prior to 1997 and they may or may not meet the minimum efficiency standard specified in the Energy Policy Act (EPAct) which took effect January 1, 1997. EPAct motors are motors manufactured since 1997 that meet the minimum efficiency standard. "NEMA Premium Efficiency" motors are the most energy-efficient 3-phase motors available with efficiencies 1 to 3% higher than an EPAct 3-phase motor for the size range of 1 HP to 200 HP. The difference between a standard motor and a NEMA Premium Efficiency motor could range from 1 % for a 500 HP motor up to 16% for a 1 HP motor. Some of the efficiency increases may seem small but for large motors and/or motors that operate 40 hours or more per week even small increases in efficiency can result in substantial savings.

High-efficiency single-phase motors are also available from several manufacturers despite there not being an industry standard. Both Baldor and Leeson manufacture motors that are 4 to 19% more efficient than standard single-phase motors. (There may be other manufacturers with high efficiency single-phase motors but the author was not aware of any at the time of writing.) The horsepower sizes available in high-efficiency versions range from 1/4 HP to 5 HP. Table 3 lists the high efficiency motor sizes available and a comparison of their efficiency with standard single-phase motors.

Power Transmission

It is important to keep motor power transmission components well maintained to keep energy costs low. This includes belt drives, chain drives, drive couplers, and gear boxes. Belt drives require the most maintenance because the belt material will elongate with age and the sides of the belt can wear, cracked or be contaminated with lubricants causing them to slip and not transfer all power. Other issues that can affect belt life include mis-alignment of pulleys and incorrect belt tension. Loose belts on a fan can affect air flow by up to 30%. Roller chain drives have the advantage of no slippage but require lubricant to maintain a long productive life. A chain running in an oil bath or having an oil drip will help maintain lubrication of the chain. The alignment of sprockets should be checked to see that they are in-line with each other to prevent premature failure. Drive couplings are designed to accommodate some misalignment between the motor and the driven component. Too much misalignment can cause the coupling to wear and fail. If the drive coupling allows for movement via a splined shaft, then lubrication will be required so the splined can move freely on the shaft. Gear box lubrication is the most important factor in maintaining long life. Gearbox lubricants may either be oil or grease and should be changed based on manufacturer's recommendations.

Table 3 – High-efficiency single phase motor efficiencies.

| Motor horsepower HP | Std efficiency motor % efficiency | High efficiency motor % efficiency |
|---|---|---|
| 1/4 | 55 | 74 |
| 1/3 | 60 | 76.5 |
| 1/2 | 62 – 68 | 78 |
| 3/4 | 74 | 83 |
| 1 | 67 | 83 |
| 1-1/2 | 75.5 | 84 |
| 2 | 75.5 | 82.5 |
| 3 | 78 | 85.5 |
| 5 | 80 – 82.5 | 86.5 |

## Energy Efficiency Grants

### Focus on Energy

Wisconsin has a state energy conservation program called Focus on Energy that offers grants for energy conserving equipment including, lighting, motors, furnaces, and grain dryers. Focus on Energy services are available to 85 percent of the homes and businesses in Wisconsin. The remaining 15 percent are customers of certain municipal or cooperative utilities that have chosen not to participate in Focus on Energy but have their own energy conservation programs. To determine if you are eligible, visit www.focusonenergy.com or call 800.762.7077 and ask for the agricultural program office. The agricultural program offers free energy audits and analysis to agricultural businesses.

### USDA 9006 Energy Efficiency and Renewable Energy Grants

The 2002 Farm Bill contains funding for grants for encourage rural small businesses to invest in energy efficient equipment and renewable energy. It is a competitive grant cycle that is usually accepts applications from mid-March to mid-June. The purchase of a high-efficiency grain dryer to replace an aging dryer would qualify under past grant rules. More information can be found at www.rurdev.usda.gov/rbs/farmbill/.

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