

Farmstead ENERGY AUDIT

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Efficient use of energy becomes very important with rising energy costs.

The purpose of this publication is to give tips on ways to reduce costs for your operation.

By reducing the amount of energy you consume, you not only will be saving money, but also reducing possible pollution and reducing the consumption of nonrenewable resources.

The following suggestions and recommendations should help you improve energy efficiency and reduce energy expenses.

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Tractor and Field Operations

Field operations are one of the largest uses of energy on most farms, so reducing or eliminating operations is helpful to examine for reductions in energy use. Conservation tillage systems conserve fuel by reducing the number of passes across fields. No-till or reduced-till systems allow farmers to prepare the seedbed, apply fertilizer and plant the crop in one operation. No-till drills or air seeders use approximately 0.7 gallon per acre.

A common conventional tillage system for crop production includes a chisel plow operation using 0.6 gallon per acre, a field cultivator using 0.3 gallon per acre and a drill using 0.5 gallon per acre, for a total of 1.4 gallons per acre. In this example, conservation tillage requires half the fuel as the conventional tillage system.

Questions to ask:

- Are you using radial tires and are they properly inflated?
- Is your tractor properly matched to the implement you are using?
- Are you reducing the engine revolutions-per-minute (RPM) speed when using a larger tractor with a smaller implement?
- Is your tractor wheel slippage excessive?
- Is a change or reduction in tillage practices possible?
- Is fuel storage shaded?
- Have your engine fuel filters and air cleaner been replaced or serviced as recommended by the manufacturer?
- Have your engine fuel injectors been cleaned and serviced properly?
- Are you using a timer on your tractor's engine heater?

Facts and Actions: Tractor Operation

- Proper maintenance as recommended by the manufacturer should be performed regularly on all field equipment. This includes replacing fuel filters, changing oil and filter, lubricating bearings and having regular engine tuneups. Implement dealers' tractor maintenance programs provide an excellent way to have equipment (especially tractors and combines) checked and maintenance operations completed by professionals (Figure 1).
- Properly inflated radial tires significantly reduce slippage, compared with bias ply tires.
- The Nebraska Tractor Test Laboratory reports the efficiency of tractors in horsepower hours per gallon, which is similar to the miles per gallon rating for cars and pickups. This allows buyers to check and compare tractor efficiencies before purchasing. A common efficiency rating for field tractors is 17 to 19 horsepower hours per gallon. The higher the number, the more power produced from a gallon of fuel.
- From an energy perspective, avoid using small implements with large tractors. For most efficient operation, the implement should be operated using the best matched tractor. If a larger tractor is used with small implements, use the principle of gearing up and throttling down to maintain proper ground speed because that will reduce fuel consumption. Be careful to not overload the engine when using this method.
- Wheel slippage generally should be between 10 percent and 15 percent for two-wheel drive tractors and 8 percent to 10 percent for four-wheel drive tractors. Wheel slippage outside of this range means the tractor is not weighted properly. If wheel slippage is greater than the recommended amount when a heavy load is pulled, more weight should be added in the form of cast iron wheel weights or fluid in the tires. Either form of weight is as effective as the other. If wheel slippage is less than the recommended amount, the tractor is carrying too much weight. This will cause the tires to sink in deeper than necessary and increases power requirements to move the tractor across the field, resulting in lower efficiency.
- Minimum or no-till practices significantly reduce tractor use and therefore save energy, money, and machinery wear and maintenance (Figure 2).
- Constantly variable transmissions (CVT) or infinitely variable transmissions (IVT) are new technologies that help improve fuel efficiency by using electronic control of transmission and engine speed for most efficient operation. The operator sets the operation speed and the controller determines engine speed and transmission setting based on load. These systems automatically perform shift up/throttle down.
- Guidance and auto-steer systems reduce overlap on field operations, increase the ability to operate longer hours (in darkness), reduce operator fatigue and improve efficiency of operations.



Figure 1. Ensure machinery is properly maintained.

(Photo courtesy of John Deere Inc.)



Figure 2. Conservation tillage reduces costs.

(Photo courtesy of John Deere Inc.)

- Diesel tractor engines generally require one to two hours of heater operation before cold-weather starts. Many farmers and ranchers leave heaters plugged in overnight. A 1,000-watt engine heater will cost \$150 a season to use (based on 10 hours per night at 10 cents/kilowatt-hour, or kwh, and a 150-day heating season). Operating that same 1,000-watt heater for only two hours each morning will save \$120, which is more than enough to pay for the cost of the timer.

Additional Resources

Tractor Test Reports. Nebraska Tractor Test Laboratory. Available at <http://tractortestlab.unl.edu/testreports.htm>

Machinery publications list. North Dakota State University Extension Service. Available at www.ag.ndsu.edu/pubs/machine.html

Conservation Tillage Seeding Equipment, AE-1351, North Dakota State University Extension Service, 2007. Available at www.ag.ndsu.edu/pubs/ageng/machine/ae1351.htm

Tractor Heater Timer Calculator. Wisconsin Public Service. Available at www.wisconsinpublicservice.com/farm/heatertimers.aspx

Grain Drying

A grain-drying system may be the most energy-intensive operation in your cropping system. For some crops, more energy is used to dry the crop than for producing. Any improvements that reduce energy needs make a major difference in total farm fuel needs.

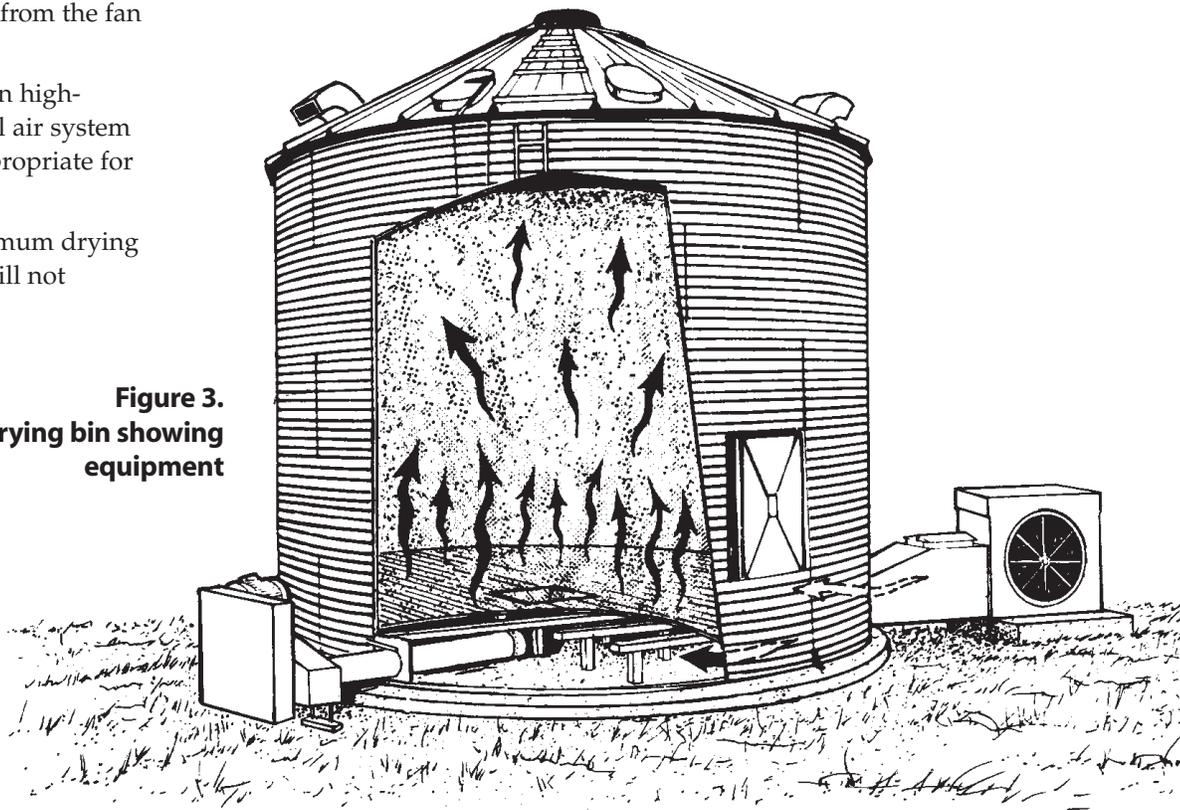
Questions to ask:

- Do you use field drying as much as possible?
- Is your moisture tester accurate?
- Are dryer burners adjusted for maximum efficiency?
- Do you avoid overdrying?
- Do you clean the grain before drying?
- Is a natural air/low-temperature drying system appropriate for you?
- Do you level the grain in a bin drying system?
- Is the transition from the fan to the bin large enough to allow unrestricted airflow from the fan to the bin?
- Would a combination high-temperature/natural air system or dryeration be appropriate for your operation?
- Are you using maximum drying temperatures that will not damage the grain?

Facts and Actions: Grain Drying

- Planting earlier-maturing varieties and drying corn in the field is generally more energy efficient and economical until mid-October, but by mid- to late October, mechanical drying is recommended. When deciding to field dry or to use mechanical drying, one needs to consider the potential for grain damage while the grain is in the field and harvest efficiency benefits gained by mechanically drying the grain.
- Removing moisture below levels required for storage or marketing reduces the quantity available to sell and increases drying costs. Ensure your moisture meter is accurate by comparing its reading to one at an elevator or to a reference. Apply a temperature adjustment to the meter reading if it is not done automatically.
- Remove broken kernels and weed seeds since they reduce dryer airflow and drying the material costs money.
- Natural air/low-temperature drying is a slow-drying system but very efficient if designed and operated correctly. Keep the depth of wheat less than 18 feet and corn less than 22 feet to limit the resistance to airflow, enabling efficient airflow delivery. Select the fan type that provides the most airflow per horsepower at the expected operating static pressure (Figure 3).
- Level the grain to create more uniform drying, which is more energy efficient and economical.
- Transitions from the fan to the bin should have a cross-sectional area larger than the fan.

Figure 3.
Drying bin showing
equipment



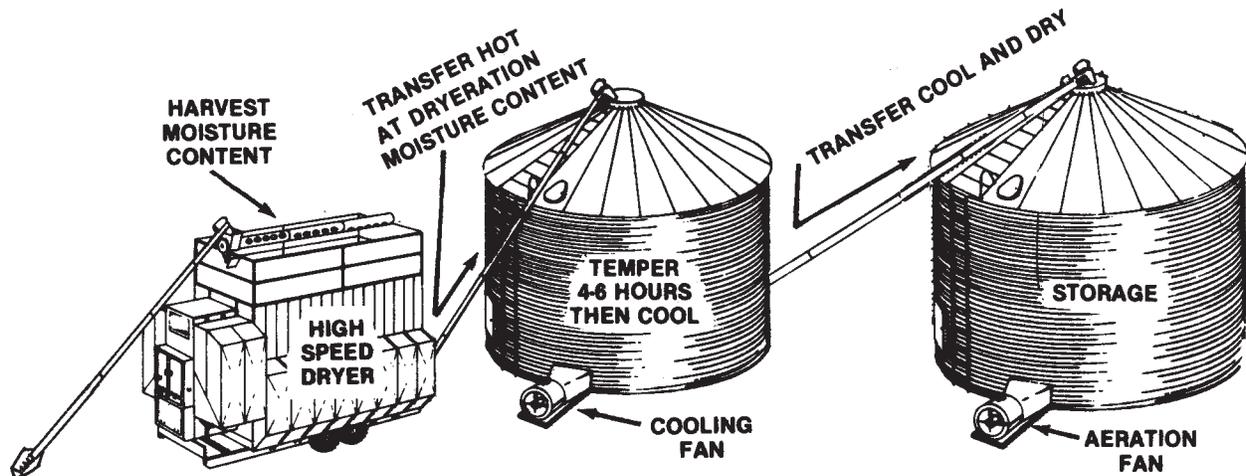


Figure 4. Schematic of dryeration system.

- The most energy-efficient high-temperature drying uses the maximum drying temperature that will not damage grain. Using vacuum cooling or a heat-recovery system increases the energy efficiency of a continuous-flow heating and cooling dryer by about 20 percent.
- Dryeration reduces the energy requirement of high-temperature drying by about 25 percent. Corn at about 130 degrees Fahrenheit (°F) coming from the dryer is steeped in a bin without airflow for four to 12 hours. Two to 2.5 percentage points of moisture are removed during cooling in the bin. Then the corn is moved to a storage bin (Figure 4).
- Combination drying uses about half the energy that a high-temperature cross-flow dryer uses. Combination drying uses a high-temperature dryer to reduce the corn moisture to less than 20 percent and then the grain is transferred hot to a low-temperature/natural air dryer to finish drying.
- Continuous-flow in-bin dryers and mixed-flow dryers may be 10 percent to 20 percent more efficient than a typical high-temperature cross-flow dryer.

Additional Resources

North Dakota State University Extension Service, crop postharvest publications. Available at www.ag.ndsu.nodak.edu/abeng/postharvest.htm

Natural Air/Low Temperature Drying, EB-35. North Dakota State University Extension Service, Fargo, N.D., 1993.

Grain Drying AE-701, North Dakota State University Extension Service, Fargo, N.D., 1994.

Maintaining Corn Quality for Wet Milling, AE-1119. North Dakota State University Extension Service, Fargo, N.D., 1996.

Grain Drying, Handling and Storage handbook, Midwest Plan Service, MWPS-13, second edition, 1987. Iowa State University, Ames, Iowa. Available at www.mwps.org

Dyeration and In-Storage Cooling for Corn Drying. 1998. University of Minnesota Extension. Available at www.extension.umn.edu/distribution/cropsystems/DC7356.html

Home

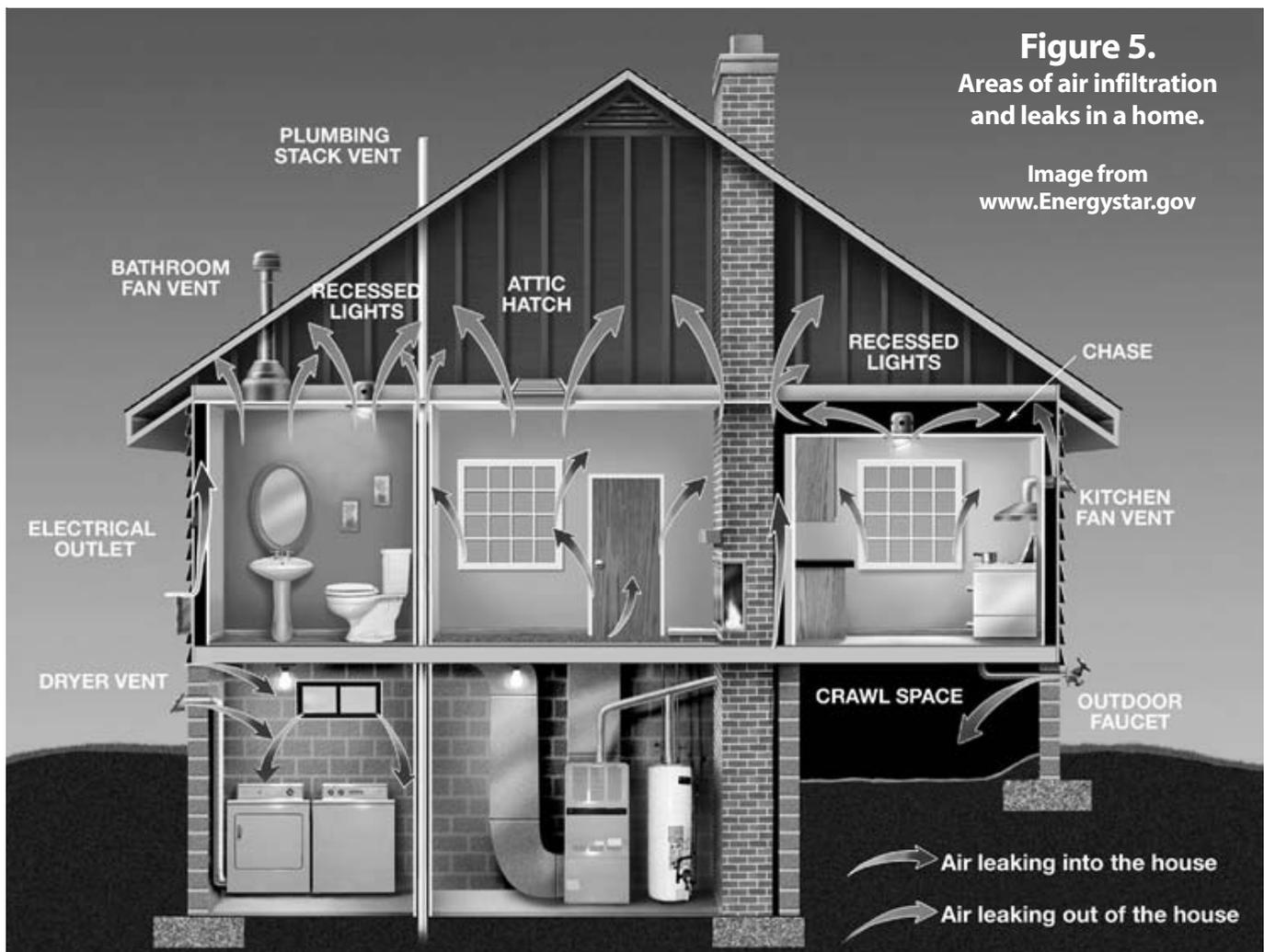
The farm home is the most used structure on the farm throughout the year. Homes should be insulated and sealed properly to keep energy use to a minimum during both the heating and cooling seasons.

Questions to ask:

- Is ceiling insulation adequate?
- Are windows sealed to restrict air movement?
- Do you have double or triple glazing on all windows?
- Is insulation placed to the eave and in the corners of the attic?
- Is the air conditioner properly sized for the home?
- Do you have insulation on the basement walls from the floor joists to at least 4 feet below ground level?
- Do you have a vapor barrier on the warm side of the wall and ceiling insulation?
- Is your furnace or boiler more than 20 years old?
- Was your refrigerator manufactured before 1993?
- Are you using a programmable thermostat or thermostat setbacks?
- Do you have trees or vegetation planted that provide shade in the summer and a windbreak in the winter?

Facts and Actions: Home

- An R-value of 49 to 60 in the ceiling and an R-value of at least 18 in the sidewall is recommended. A rough estimation to use, depending on insulation type, is that an R-value of 49 is equivalent to at least 16 inches of blown-in insulation.
- Be sure to provide an air space between the eave inlets and the attic space. Blown-in insulation easily can fill between the roof joists, limiting air movement from the eave to the attic. Vents (air chutes) are available and can be installed between the roof joists to help maintain space for air movement.



- The attic space needs to be ventilated with eave and roof or gable vents to keep heat from building up under the roof deck. Heat under the roof in the winter is the major cause of ice dam formation on a roof.
- Air infiltration is a major energy waster. To limit this, caulk should be installed between the window frame and the siding. A wind-retardant barrier should be placed under the siding (Figure 5).
- All doors should have weather stripping around the edges to produce a good seal with the frame. Replace worn weather stripping.
- All windows should be double or triple glazed. A single-glazed window will have an R-value of about 0.9. A double-glazed window with an inert gas between panes will have an R-value of between 3.0 and 4.0.
- Basement walls made of concrete or concrete blocks are poor insulators. Any part of the wall that extends above ground and 4 feet below the soil surface loses a considerable amount of heat. This occurs even if the basement is not heated. At least 2 inches of an extruded foam board should be installed on the walls extending at least 4 feet below ground level if the basement is not insulated on the inside.
- Air conditioning is another large user of energy. A well-insulated and tight home will help reduce this cost. Setting the thermostat at 76 °F should provide comfort for most people and keep energy costs at a reasonable level.
- Replace an older furnace or boiler with a high-efficiency unit with an efficiency greater than 90 percent.
- Regular maintenance is important on furnaces to make sure they are operating efficiently. Check filters monthly to ensure air flow is not restricted.
- Replace refrigerators that are more than 15 years old. New Energy Star models can save up to half of the

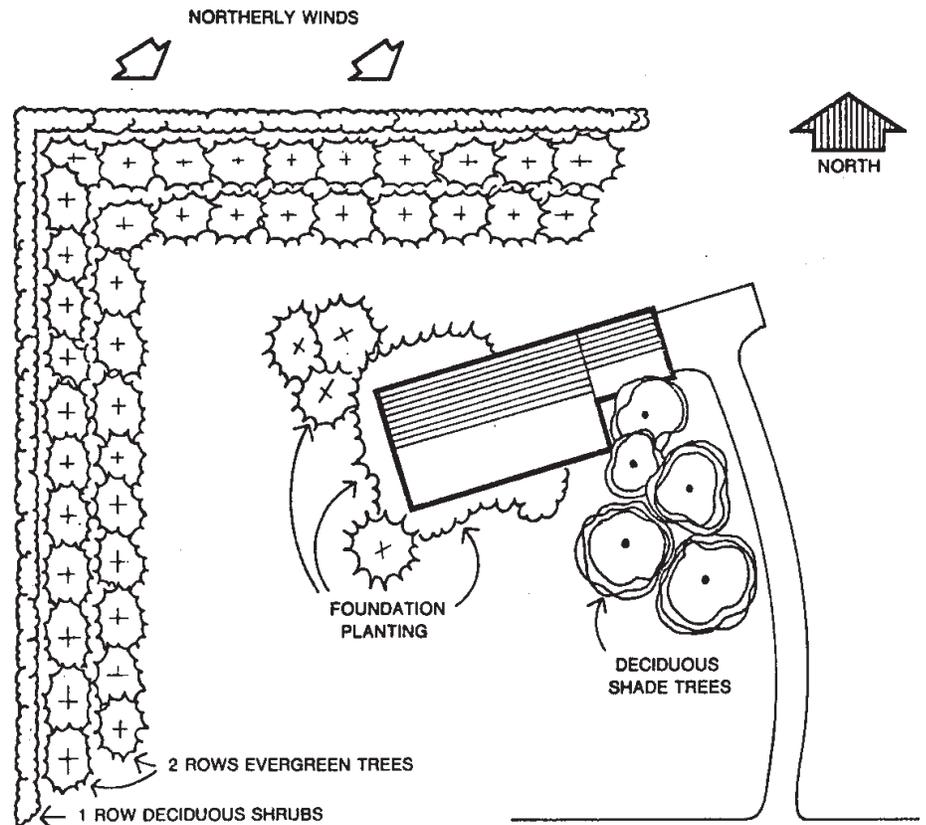


Figure 6. Recommended placement of shelterbelt for a farmstead.

energy that refrigerators made before 1993 will use.

- If your hot water heater is not a new, high-efficiency model, install an insulation blanket to reduce standby losses. Insulation blankets are inexpensive and pay for themselves in energy savings within a year.
- Flush your water heater monthly to reduce sediment buildup in the bottom. Sediment buildup reduces heating efficiency of the water heater.
- Programmable thermostats can lead to significant energy savings. Turning down the thermostat when your home is not occupied or at night can result in a 1 percent savings for each degree the thermostat is lowered for an eight-hour period.
- Planting shelterbelts around homes and other buildings is a natural way to reduce heating and cooling costs. Planting deciduous trees on the south and west sides of buildings

reduces the need for air conditioning in the summer. In the winter, the plants lose their leaves, allowing the sun to penetrate and help warm the house. Plant evergreen trees on the north side of the house to reduce the impact of wind on heating during winter months (Figure 6).

Additional Resources

Consumers Guide to Home Energy Savings, 9th edition. American Council for an Energy-Efficient Economy. Available at <http://aceee.org/Consumer/index.htm>

U. S. government Web site for the Energy Star program. Resources include home improvement recommendations, Energy Star products and appliance recommendations. Available at www.energystar.gov

Wind and Snow Control Around the Farm. Purdue University Extension Service, West Lafayette, Ind. 1983. Available at www.ces.purdue.edu/extmedia/NCR/NCR-191.html

Indoor and Outdoor Lighting

The design and management of your lighting system greatly affects efficiency. Lighting efficiency is related to the light output reported as lumens and the amount of energy used. Select bulbs that produce the most lumens per watt of electricity. Use sunlight as often as possible; it is generally the most efficient.

When choosing lighting, remember fluorescent lamps produce more lumens per watt than incandescent bulbs. Fluorescent lamps and sodium vapor lamps are more efficient than mercury vapor lamps.

Questions to ask:

- Are lights off if they are not needed?
- Are light fixtures kept clean?
- Can you use localized lighting instead of general lighting for the job?
- Can incandescent bulbs be replaced with compact fluorescent lamps (CFLs)?
- Can high-intensity discharge (HID) lamps (metal halide, sodium vapor or T8 fluorescent lamp) be used?
- Are lamps in the best location for the job?
- Would timers be beneficial in turning lights on and off?
- Would lights controlled with a motion sensor be a possibility?



Figure 7. Halogen yard light with a motion detector.

Facts and Actions: Steps on Lighting

- Incandescent light bulbs are significant energy wasters. Replacing incandescent bulbs with CFLs can provide immediate savings. An incandescent bulb that uses 100 watts of electricity can be replaced with a 23-watt CFL. The 23-watt CFL produces the same amount of light but uses more than 75 percent less energy. If you replace five 100-watt incandescent bulbs with CFLs, you can save \$54.02 per year (based on 10 cents/kwh and four hours of use per day). CFLs also have longer average life, lasting 6,000 to 10,000 hours versus about 1,000 hours for an incandescent bulb. CFLs are not generally recommended for outdoor

use due to poor performance in unheated or low-temperature areas.

- Security yard lighting historically has used mercury vapor lights. Newer, more efficient options are available. Mercury vapor lights produce 32 lumens per watt of power, while metal halide lights emit 62 lumens per watt and high-pressure sodium lights produce 95 lumens per watt. Many people opt for pulse-start metal halide lights even though they are less efficient because they produce a light that has a truer color than the yellow light emitted by high-pressure sodium lights.
- Timers can ensure that your lights will be turned off during hours when they are not needed. Daylight sensors, motion detectors

Table 1. Comparison of lamp types. From Energy Efficient Agricultural Lighting (see link in resources).

Lamp Type	Lumens/watt	Average life (hours)	Color	Starting temperature (°F)	Instant on	Contains mercury
Incandescent	7-20	100	White	>-40 °F	Yes	No
Halogen	12-21	2-6000	White	>-40°F	Yes	No
Mercury Vapor	26-39	24,000	White-blue	-22°F	No*	Recycling recommended
Compact Fluorescent	45-55	6,000 -10,000	White	-20°F or 0°F	Yes	Recycling recommended
T-12 HO Fluorescent	30-70	9,000 - 12,000	White	-20 °F	Yes	Recycling recommended
Metal Halide	41-79	10,000 - 20,000	Bluish	-22°F	No*	Recycling recommended
Pulse Start Metal Halide	60-74	15,000 -32,000	Bluish	-40°F	No*	Recycling recommended
T-12 (1.5-inch) Fluorescent	62-80	9,000 – 12,000	White	50 °F	Yes	Recycling recommended
T-8 HO Fluorescent	81	18,000	White	-20 °F	Yes	Recycling recommended
High-pressure Sodium	66-97	24,000	Yellow-orange	-40 °F	No*	Recycling recommended
T-8 (1-inch) Fluorescent)	76-93	15,000 – 20,000	White	0 °F	Yes	Recycling recommended
T-5 (5/8-inch) Fluorescent #	83-85	20,000	White	0 °F	Yes	Recycling recommended

* Requires warmup to reach full output; #: not recommended for ag applications

and timers can be set for security yard lighting that turns on at night or when motion occurs and then turns off after a few hours when activity is lower, after midnight for example.

- Cleaning dust off reflective surfaces of light fixtures will help maintain light output. Dust absorbs light waves and will reduce the output of lights.
- Providing spot lighting for work areas can reduce the need for more costly general lighting.

- HID lights consume 50 percent to 90 percent less energy than comparable incandescent bulbs, but take several minutes to achieve rated intensity. They generally are used to illuminate large areas.
- Motion sensors can be used to turn lights on in areas when someone enters the room or motion occurs outdoors. They then turn the lights off after a period of time when no motion is sensed, eliminating unnecessary electrical usage.

Additional Resources

Energy Efficient Agricultural Lighting, University of Wisconsin, Madison. Available at <http://learningstore.uwex.edu/Energy-Efficient-Agricultural-Lighting-P132C29.aspx>

U. S. government Web site for the Energy Star program. Available at www.energystar.gov

General electric online calculator to determine savings by replacing incandescent bulbs with CFLs. Available at www.gelighting.com/na/home_lighting/products/pop_lighting_calc.htm



Figure 8. Energy efficient lights.

Farm Shop

The farm shop is often the second most used building during the winter after the home. It needs to be well-insulated and sealed to keep energy use to a minimum.

Questions to ask:

- Is insulation adequate in the walls, ceiling and doors of the shop?
- Do the doors fit tightly to limit air infiltration?
- Do you have insulation around the shop floor and foundation that extends at least 2 feet below ground?
- Do you use your waste engine oil for heating the shop?
- Do you have good, economical lighting in the shop?
- Do you have a minimal amount of windows in the shop?
- Are windows double glazed?
- Do large shop doors face south or east?
- Do you have a dense shelterbelt on the west and north side of your farmstead?

Facts and Actions: Farm Shop

- Insulation with an R-30 to R-40 value in the ceiling and R-18 value in the sidewalls is recommended. Doors should have an R-value of 10 to 12.
- If doors do not fit tightly and allow significant amounts of cold air in, weather stripping should be installed. Air infiltration is one of the largest heat wasters in many buildings.

- Insulation around the shop foundation should be at least 2 inches of extruded polystyrene (enclosed cell insulation) installed at least 2 feet below ground level. Any concrete exposed above ground level needs insulation and the insulation above ground needs to be covered to prevent damage from birds, rodents and sunlight. Be sure to extend the insulation cover well below ground level (6 inches or more).
- Waste engine oil is an excellent source of heat. Used engine oil tends to accumulate extremely fast during times when farm engines are operating. Store this oil in a large barrel to use for heating during the winter. Several manufacturers make waste oil heaters and many heaters can use fuel oil if the waste oil runs out.
- Large or many windows increase heat loss and limit useable wall space for tools. They usually provide little light in the shop as the days are short in winter and the light they provide is usually near the wall where they are installed.
- Good overhead lighting is a necessity in a shop. Use metal halide or T-8 fluorescent lamps for economical lighting that will keep electricity use to a minimum and give good lighting to work on equipment. Metal halides are slow to come on, so one or two incandescent bulbs may be helpful to provide light when you enter the shop.
- Double- or triple-glazed windows help reduce heat loss and moisture condensation. A window with single glazing will have an R-value of about 0.9, whereas a double-glazed window with an inert gas between panes will have an R-value of 3.0 to 4.0
- The large doors for bringing machinery in and out of the shop should face away from prevailing winter winds. Prevailing winter winds are usually from the northwest. Installing the large doors facing south or east will prevent a considerable amount of heat loss when doors are opened.
- Use zone heating. Heat only the areas that need to be heated. Directional heaters over work benches are examples. Separating the shop from the storage area, even with a plastic curtain, can save a significant amount of heat.
- Dense shelterbelts reduce the wind velocity and reduce the energy needed to heat the shop. Short, dense trees should be located on the edge of the shelterbelt and the taller trees located in the middle. Shelterbelts should be at least 100 feet from the shop to reduce the problem of snow buildup near the shop.

Additional Resources

Planning Farm Shops, AE-1066, North Dakota State University Extension Service, Fargo, ND 58105. Available at www.ag.ndsu.edu/pubs/ageng/structu/ae1066w.htm

Farm Shop Plans Book, MWPS-26, Midwest Plan Service, Iowa State University, Ames, Iowa. Available at www.mwps.org

Irrigation

Agricultural irrigation is an energy-intensive operation. Pressurized irrigation systems, especially center-pivot sprinkler, use a high flow-rate pump and require a large electric motor or engine. The major causes of increased energy use are with pipeline leaks, engine efficiency, pump efficiency and well maintenance. Poor water application uniformity also can affect energy use by increasing pumping time. On center-pivot systems, the major causes of poor water application uniformity are worn or wrong size sprinkler nozzles, missing sprinkler heads and leaking boots. Using a consistent method of irrigation scheduling during the growing season can optimize water application.

Questions to ask:

- Do you have a good procedure for determining when to irrigate and how much water to apply? Do you use evapotranspiration (ET)-based irrigation scheduling?
 - Are the sprinkler nozzles on your center pivot providing a uniform application pattern along the full length? Have the sprinkler heads and nozzles been on the pivot more than seven years? Have you checked nozzle sizes to see that they match the nozzle sizes listed in the sprinkler package printout from your dealer?
 - Do you annually check for pipeline leaks, missing nozzles and nozzles that are not rotating properly?
 - If you have an engine powering the pump, do you change the oil and filter according to manufacturer recommendations? Are the pump and motor or engine receiving regular annual maintenance?
 - Do you record the static and pumping water levels in the well every year?
- If you have iron in the irrigation water, do you chlorinate the well each year?
 - If you have an electric motor, can you subscribe to controlled electric rates (off-peak) from your electric supplier?

Facts and Actions: Irrigation

- Use of consistent irrigation scheduling often can reduce energy use by 7 percent to 30 percent. Using an ET-based irrigation scheduling system can ensure you are not under or overwatering the crop.
- The average life expectancy of a sprinkler head is about seven years. Sprinkler head nozzle diameter is very important for uniform water application and the nozzle diameter can increase with use, especially if sand or grit gets into the water. Poor application uniformity increases water pumping time and therefore energy use. Replace broken sprinkler heads as soon as possible. Do a “can test” to check the uniformity of the application pattern. Repair all leaks on the center pivot as soon as they are noticed.
- Buried pipelines rarely have leaks unless they were not pumped out before winter. However, above-ground pipelines frequently have worn gaskets and up to 30 percent of the water can be lost. Replace leaking gaskets and plug any holes.
- The drawdown in a well increases if the screen becomes plugged, greatly increasing pumping costs. Screens become plugged due to mineral incrustation or iron bacteria. Mineral incrustation occurs through time. By measuring the static and pumping water levels each year, the increase in drawdown can be measured and corrective action initiated. Iron in the water usually means iron bacteria are present in the well.

Annual chlorination will control the iron bacteria.

- Regular pump maintenance includes proper greasing and filling oil reservoirs every year. Proper adjustment of packing glands and adjusting impellers on deep well turbines on a regular basis are very important. Replacing diesel pump motors with electric motors can have significant cost savings.
- Most electric suppliers offer controlled (off-peak) electric rates for irrigation pumping systems. Using off-peak power rates can reduce pumping costs significantly, compared with regular power rates. However, off-peak rates should not be used with high-value crops such as potatoes and onions. Ask your electric supplier whether off-peak power rates would work for your operation.

Additional Resources

- Care and Maintenance of Irrigation Wells, AE-97. North Dakota State University Extension Service. Fargo, N.D., 2005. Available at www.ag.ndsu.edu/pubs/ageng/irrigate/ae97w.htm
- Irrigation Water Pumps, AE-1057. North Dakota State University Extension Service. Fargo, N.D. 1993. Available at www.ag.ndsu.edu/pubs/ageng/irrigate/ae1057w.htm
- Irrigation Scheduling Checkbook Method Tutorial. University of Minnesota Extension Service, 2002. Available at www.extension.umn.edu/distribution/cropsystems/DC1322.html
- Irrigation testing – link to uniformity testing procedure (can test) and spreadsheet for calculating coefficient of uniformity. University of Wisconsin-Madison. Available at www.uwex.edu/energy/irrigation.html
- Energy Saving Tips for Irrigators, National Sustainable Agriculture Information Service. 2006. Available at http://attra.ncat.org/attra-pub/PDF/energytips_irrig.pdf

Livestock Buildings

Ventilation is needed in confined livestock structures to remove heat and moisture and maintain air quality. The amount of ventilation needed varies depending on outside air temperature, inside temperature, amount of moisture to be removed, odors to be controlled and the heat produced by the animals and equipment.

Reducing the energy needed for ventilation equipment involves determining the number of fans needed to do the job and operating only those fans for as short a time as possible. For example, winter ventilation usually will be less than spring or fall ventilation and much less than summer ventilation. Summer ventilation is usually high due to high heat loads. Winter ventilation is usually low due to only needing enough air exchange to remove moisture and maintain air quality. Fan efficiency is reduced if obstructions are near or in front of fans.

Improved energy efficiency for livestock buildings has been made possible through several advances in technology. Examples can be found in efficient heat lamps, creep pads and more energy-efficient milking operations.

Questions to ask:

- Are fan blades, motors and housings clean?
- Can you use natural ventilation successfully?
- Are ventilation fans the right size for the number of animals in the building?
- Do automatic controls work for your application?
- Would zone heating and ventilation systems be appropriate?
- Would an air-to-air heat exchanger be appropriate?
- Is insulation adequate to prevent condensation problems?
- Are heating systems for livestock adjusted properly?
- Are thermostats accurate and located so that they are not affected by drafts and direct sunlight?
- Is more building insulation necessary?
- Are you using the most energy-efficient technology for your livestock operations?

Facts and Actions: Livestock Buildings

- Keeping dust off fan components helps motors operate at a cooler temperature and prolongs their life. Clean blades move more air. Dirt, chaff and animal hair clinging to protective guards reduces air flow.
- Natural ventilation uses airflow passages that allow clean air to enter a building and displace stagnate or dirty air at a natural exit. This is caused by a difference in building pressure and atmospheric pressure or thermal buoyancy of air. Using natural ventilation wherever possible will save energy by reducing the number of ventilation fans needed for an air exchange. Opening curtain side walls with buildings that are equipped with them is an example.
- Sizing fans correctly for building ventilation is important. Fans larger than necessary waste energy and will produce a cold air blast in the winter, while undersized fans will not adequately exchange building air.
- Automatically controlled ventilation systems reduce unnecessary fan operation and provide more uniform climate control. Variable-speed controllers can be used to control the amount of air exhausted by slowing or increasing the speed of a fan based on the building temperature.
- Select fans that are energy efficient. Fan efficiency is measured as cfm/watt (cubic feet per minute per watt) or air moved per energy consumed at a specific static pressure. The difference between the best and worst performing fans is two-fold; therefore, if you make a poor choice, ventilation costs could be twice what they could have been by choosing a more efficient fan.

Two sources of independent test data for ventilation fans are available: 1) BESS Lab – University of Illinois and 2) Air Movement Control Association. Both have on online access to fan test results; see links below.

- Fans with diffuser or discharge cones are 12 percent to 26 percent more efficient than fans without them.
- Large-diameter fans are more efficient than smaller-diameter fans.
- Significant energy savings can be achieved through zone heating. The savings come from heating or ventilating only rooms or areas of buildings that are used or need more climate control.
- Insulation in livestock confinement buildings is necessary to reduce heat loss and reduce the problem of condensation on walls and ceiling.
- Beef and dairy calves may not require supplemental heat unless they are born in very inclement weather. A “hot box” or homemade spotlight heating unit may be useful for this purpose.
- Baby swine and poultry require very precise temperature and humidity regulation that is normally engineered into the building; however, additional or spot heat can be provided if required. Certain safety precautions need to be considered. Heated creep pads for swine are more energy efficient than heat lamps and provide more evenly distributed warmth.
- On dairy farms, using variable-speed drives for vacuum systems can save up to 60 percent on energy costs normally spent moving the milk.
- Milk precoolers likely will save 15 percent to 30 percent per month on milk cooling energy costs. The precooler uses well water to cool the milk before it goes into the bulk tank.



Figure 9. Livestock air ventilation system.

Additional Resources

Agricultural Ventilation Fan Performance Tests. BESS lab University of Illinois, Urbana, Ill. Available at www.bess.uiuc.edu/type.asp

Air Movement Control Association. Available at www.amca.org/

Fan Performance and Efficiency for Animal Ventilation Systems. University of Minnesota Extension Service, 1994. Available at www.extension.umn.edu/distribution/livestocksystems/DI0956.html

Save Energy in the Farrowing Room with Hovers. University of Minnesota Extension Service, 1994. Available at www.extension.umn.edu/distribution/livestocksystems/DI6513.html

Dairy Farm Energy Management Handbook. Wisconsin Department of Agriculture, Trade and Consumer Protection. Available at <http://datcp.state.wi.us/fs/environment/dfmh/index.jsp>

Midwest Plan Service publications: Low-cost agricultural publications available through Iowa State University at www.mwps.org

Beef Housing and Equipment Handbook, Midwest Plan Service, MWPS-6. Fourth Edition, 1987.

Dairy Freestall Housing and Equipment, Midwest Plan Service, MWPS-7. Seventh Edition, 2000.

Swine Farrowing Handbook, Midwest Plan Service, MWPS-40. 1992.

Sheep Housing and Equipment Handbook. Midwest Plan Service. MWPS-3. Fourth Edition, 2002.

Horse Facilities handbook. Midwest Plan Service, MWPS-60. 2004.

Livestock Water Systems

A dependable supply of drinking water is essential in any livestock production facility. Keeping the water from freezing is important so the animals can drink at any time.

Most of the energy used by a livestock water fountain is used to keep the water from freezing. Insulation around the automatic waterer or water tank and protection from the wind will help reduce the heat loss and thereby reduce the energy needed.

Keeping float valves in good condition so they don't stick open or leak will reduce energy needs by reducing the amount of water that must be pumped, heated or evaporated. The amount of ice and mud around waterers also will be reduced.

Questions to ask:

- Are you using a water fountain with a covered water surface?
- Do water bowl covers fit snugly, but can be easily opened by livestock?
- Is the thermostat set so that the water does not freeze but not so high that it turns the heater on when livestock drink? (32 to 34 °F)
- Is the thermostat working properly?
- Is good wind protection around the water fountain?
- Do float valves leak?
- Would extra insulation be beneficial? Can it be installed?
- Is the waterer the right size for the number of animals?

Facts and Actions: Livestock Water Systems

- Adequate water for livestock is essential. Water fountains that overflow are costly from the standpoint of pumping the excess water or purchasing the water from a rural water supplier.
- Improperly working thermostats are a common problem. Test to make sure the thermostat is functioning correctly.
- Adjust thermostats to maintain frost-free water. Groundwater temperatures are generally between 42 °F and 52 °F, so make sure the setting is below that level so the heater does not turn on when animals drink. Thermostat settings from 32 to 34 °F will provide frost-free water.
- Energy-free or frost-free water fountains can be operated without the need for a heater even in harsh winters of the northern Plains. These types of water fountains cover the water surface with balls, lids or small openings to reduce heat losses. They require no supplemental energy, but require a minimum number of animals drinking from the fountain to keep from freezing. They can save \$60 to several hundred dollars per year, depending on the type of fountain (Figure 8).
- Insulate the concrete surface inside fountains and add insulation inside the fountain body and inside the top 3 feet of the riser pipe.
- When installing the fountain, use 12-inch-diameter (minimum) heat well for riser pipe.
- Make sure to protect the water fountain from the wind.



Figure 10. Energy-free livestock water fountain.

(Photo courtesy of Ritchie Industries Inc.)

Additional Resources

Energy Free Water Fountains,
Agri-fact, Alberta Agriculture and
Rural Development, Alberta, Canada.
Available at [www1.agric.gov.ab.ca/
\\$department/deptdocs.nsf/all/eng3133](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng3133)

Midwest Plan Service publications:
Low-cost agricultural publications
available through Iowa State
University, Ames, Iowa, at
www.mwps.org

Beef Housing and Equipment
Handbook, Midwest Plan Service,
MWPS-6. Fourth Edition, 1987.

Dairy Freestall Housing and
Equipment, Midwest Plan Service,
MWPS-7. Seventh Edition, 2000.

Swine Farrowing Handbook, Midwest
Plan Service, MWPS-40. 1992.

Sheep Housing and Equipment
Handbook. Midwest Plan Service.
MWPS-3. Fourth Edition, 2002.

Horse Facilities handbook. Midwest
Plan Service, MWPS-60. 2004.

Summary

This is not a complete list of ways to make your operation more cost effective and energy efficient. The hope is that this guide will serve as a starting point for energy savings and that you will consider additional items that are specific to your operation.

If you have questions about techniques for implementing any conservation measures, contact your local Extension office. Additional sources of information can be found at the following Web sites:

- The U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, at www.eere.energy.gov/
- North Dakota Department of Commerce, Office of Energy Efficiency and Renewable Energy Programs, found at www.nd.gov/dcs/energy/
- North Dakota State University Extension Service, Fargo, N.D., energy home page found at www.ndsu.edu/energy

**For more information about energy
from the NDSU Extension Service:
www.ndsu.edu/energy**

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