Energy Efficient Farms

Identifying the Proper Improvements

A PUBLICATION OF

the MINNESOTA PROJECT

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ABOUT THE MINNESOTA PROJECT The Minnesota Project is a nonprofit organization championing the sustainable production and equitable distribution of energy and food in communities across Minnesota. The organization focuses on three areas: the development and efficient use of clean renewable energy, promotion of sustainable agriculture practices and production, and consumption of local, sustainably grown food.

Founded over 30 years ago, today's team works toward establishing a sustainable Minnesota by 2039 through policy research, education and outreach, as well as developing key ground-up, grassroots initiatives targeted at empowering communities and their leaders.

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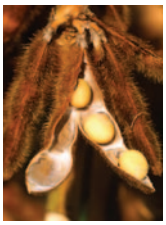


Efficient energy use in farm applications is an important, though often overlooked, component of running a profitable and successful farming operation. Experts estimate that energy costs account for about 10% of a typical farm's budget.[1] Therefore, making energy efficient improvements can save farmers significant amounts of money. This opportunity is especially important in a time when most farmers operate on margins that are highly scrutinized and tailored down to the last dollar. When implemented correctly, energy efficiency improvements can help widen the operating margin and give added flexibility to maintain or increase the farm operation. The Minnesota Project's ***Energy Efficient Farms:*** *Identifying the Proper Improvements*, will introduce core practices and technologies that can help farmers save money on their energy budgets through increased operation efficiency.

We hope this publication provides useful information that will help farmers begin to undertake energy efficiency improvements on their farm.

This publication is split into three sections. The first section is designed to give a quick overview of tools and services available to determine the current energy use on the farm and which areas that could be most economized through energy efficiency improvements. This section is supplemented by the Minnesota Project's other recent publication, ***Improving Farm Energy Efficiency:*** *A Guide to Navigating the Process*. Together, these documents will provide a number of options – ranging in depth, focus, and cost – for identifying potential areas for farm energy efficiency improvements.

The document's second section, "Improving Energy Efficiency through Common Farm Technology," addresses technologies in use on virtually all Minnesota farms and how these technologies can be economized, through energy efficiency improvements. This section addresses common farm technologies such as lighting, HVAC systems, and electric motors and pumps. While these categories may seem quite general, the content is focused on useful information that can be acted upon to save money.

The third section of this publication, "Farm Specific Efficiency Improvements," focuses on energy efficiency practices that apply to only certain types of farm operations. The section is broken into chapters that focus on areas like cash crop, dairy, and others. Each of these chapters contains specific information that is most relevant for farmers working exclusively in these areas, and can be used to help determine whether a given efficiency improvement would be beneficial to the operation.

In addition, there are three themes common to each section: Financial assistance, preventative maintenance and technology upgrades, and online tools and resources.

Financial Assistance. Basic information regarding utility rebates is provided at the beginning of each chapter. Utility rebate information provides average utility rebates for various technologies, compiled from information across the state. These rebates help defray the cost of making energy efficiency improvements. Specific rebates may or may not be available in your area, so confer with your local utility to determine what assistance they have available. Keep in mind, other financial assistance may be available to assist in implementing energy efficiency improvements in the farm operation. The Minnesota Project's "Navigating the Process" guide will provide further financial assistance information.

[1] Government programs and Technology: Finding the Right Technology and Finding the Right Source to Help You Fund it. Institute for Energy and the Environment. http://www.agenergysolutions.org/site/?page_id=9.

Preventative Maintenance and Technology Upgrades. Each of the chapters contains two distinct parts: preventative maintenance and technology upgrades. The first part provides advice regarding preventative maintenance and/or low cost energy efficiency improvements that can be made from the outset that will increase your operation's energy efficiency with little cost. Second, this guide suggests potential technology upgrades that could be made to improve your operation's energy efficiency by a wider margin, through technology investment.

Tools. Each chapter concludes with a list of tools that may be useful in helping you take a first step toward learning about the benefits of efficiency improvements in each specific farm area addressed in this document. While these tools may not provide the most in depth information available, they are often helpful in helping a farmer learn about the efficiency of a specific part of the farm operation.

Overall, we hope this publication provides useful information that will help farmers begin to undertake energy efficiency improvements on their farm. There's no doubt that making energy efficiency improvements will require some hard work. But hard work is figured into any part of running a successful farm. We're excited to provide this information because hard work invested in this area of farm operation will result in a better running farm and increased savings in your bottom line.

SECTION I

Evaluating Your Energy Efficiency Needs

The first step in making a farm energy efficient is to determine which parts of the operation are not operating at their highest efficiency. Energy audits, energy use self assessments, and energy awareness tools can be a great way to see how much energy an operation currently uses, along with what types of savings can be made through a few simple changes.

This section provides a brief outline of the types of tools and services available to help farmers decide what changes will most benefit their operation.

Chapter 1: Energy Audits

Energy Audits are a good way to determine how much energy is being consumed and what can be done to reduce energy consumption. Traditional audits, performed by a member of your local utility, or a qualified third party, provide the most comprehensive review of your farm. Your utility likely has a person on staff that can help perform such an audit, or will refer you to someone who can. Often, they'll help defray the cost of the audit as well. Using this method, an expert will visit your farming operation and inform you of energy saving technologies and techniques specifically for your farm. They'll let you know of current rebates and tax incentives for installing energy saving devices and can help isolate where your biggest savings will be, so you don't have to do everything at once.

For an example of a typical comprehensive farm energy audit, take a look at this example from a dairy farm in Maine:

www.mainerural.org/energy/fieldguide/broadacresaudit.pdf

For more information on Energy Audits and Self-Assessments, check out The Minnesota Project's other publication, ***Improving Farm Energy Efficiency: A Guide to Navigating the Process***.

Energy audits can be very simple or very complex but they all contain two basic prongs[2]:

- First, an audit seeks to characterize your current energy usage. This can be done through on-site inspection or by keeping track of energy use over a period of time. On-site inspections will make note of the various sizes and energy needs of all the energy consuming equipment on your farm. The inspection will then use this data in conjunction with your average hourly use of each piece of equipment to determine your largest energy consuming practices.
- Second, an energy audit will describe the possible changes that could reduce energy consumption, with a focus on the areas that provide the best return on investment.[3] An energy audit makes its recommendations based on the amount of energy use an efficient technology would consume, if used in a role similar to your operation. The audit will also base its recommendations on equipment affordability and its rate of return through energy saving.

Perhaps the most important point to remember about energy audits is that they won't save you anything by themselves. Farm operators need to be deliberate in their energy saving choices on the farm. After an audit or energy evaluation, they must work hard to practice any no cost energy conservation techniques and should implement the energy efficient technologies that make economic sense for the farming operation. Delaying the implementation of these changes prolongs energy waste and prevents an operator from realizing the economic benefits of energy efficiency.

For more information on how to secure an energy audit on your farm, contact your local utility.

[2] Farm Energy Audits: Availability, Usefulness and Cost, National Center for Appropriate Technology, September 2009.

[3] Farm Energy Audits: Availability, Usefulness and Cost.

Chapter 2: Energy Self Assessments

An energy self assessment allows a farmer to do much of the information gathering of an audit on his own to take control of his energy use and determine the best areas for lowering his energy budget. A self assessment, while less precise than a full blown audit, can be a good start to help a producer begin considering efficiency changes on their operation.

Self assessments have risen in popularity with the development of useful do-it-yourself tools, often found online. Two of the most prominent tools are energy use worksheets and energy use calculators.

Energy Use Worksheets

- Energy use worksheets help a farmer characterize energy use by running down a list of equipment commonly found on a farm and providing a typical energy consumption rate for each piece of equipment. The farmer can then proceed through the worksheet, filling in the average daily, weekly, or monthly use of each piece of equipment. By multiplying an average consumption rate by the hourly use, a farmer can begin to get a picture of the largest energy uses.
- Many utilities provide simple worksheets that can be filled in by the customer to aid in categorizing a farm's energy use.[4] These worksheets are quite helpful in reminding operators of oftentimes overlooked technologies on their farm that use electricity.

Energy Calculators

- Energy calculators, usually found online at various energy efficiency websites, are simple online tools farmers can use to assist them with their self assessment. Often these tools also include general advice on how much electricity could be saved through implementing differing energy efficiency practices.
- These calculations will not be as extensive or precise as an energy audit, but provide help for farmers attempting to conduct a more thorough self assessment.
- To find an online tool that works well for your operation, the following websites provide multiple calculators that will help diagnose potential savings on your farm.
  - USDA Energy Estimators: http://energytools.sc.egov.usda.gov/
  - Energy Calculators: http://attra.ncat.org/energy_calculators.html

[4] One example of an energy consumption worksheet: http://www.fmcs.coop/farmenergy.htm.

SECTION II

Improving Efficiency through Common Farm Applications

The following section highlights energy efficiency improvements for technologies widely used on all types of farms. Therefore, rather than repeating the same information multiple times, the areas of lighting, motors and pumps, and HVAC are each addressed in their own specific chapters.

As you read through these chapters, make note of the improvements that would work best on your operation.

Utility Rebates!

Lighting

Average Utility Rebates for Energy Efficient Lighting Improvements:

- Most utilities pay significantly higher rebates for retrofits/ replacements over new construction.
- Some light bulb rebates based on average wattage saved; $0.03 - $0.10 per watt saved
- Other light bulb rebates based on bulb type and size
  - CFL bulb rebates: $2-6 per bulb
  - T-5 lamp rebates: $2.50 (new), $13-20 (replacement/retrofit) per lamp
  - T-8 lamp rebates: $2.50 (new), $13-20 (replacement/retrofit) per lamp
- CFL fixture rebates: $10-20 per fixture
- T-8 fixture rebates: $5-20 per fixture; based on fixture size
- T-5 fixture rebates: $3-12 per fixture; based on fixture size
- High Pressure Sodium fixture rebates: $20-50 per fixture
- Metal Halide Lamp fixture rebates: $15-50 per fixture

Chapter 1: Lighting

Energy used for lighting makes up a large part of any farm's energy bill. Various energy professionals have estimated lighting to account for anywhere from 15-30% of total energy costs.[5] The good news is lighting is one of the simplest and inexpensive areas to reduce energy use and costs. Using a few simple techniques, the amount of energy used for lighting can be significantly reduced.

Preventative Maintenance: Low-Cost Improvements

Basic maintenance of lights and light fixtures, sometimes in place of potentially costly replacement equipment, can keep lights burning at their optimal energy efficiency. Consider these tips as a first step toward energy efficiency.

- Clean fixtures, lamps and lenses every 1 to 2 years to make sure you are receiving the full benefit of the light produced by your light fixtures. You'll need to replace lenses on light fixtures if they appear yellow. This will allow light fixtures to work at their full potential.
- Keep walls and small areas clean and repainted every 2-3 years so they reflect the maximum amount of light.[6]
- Consider changing all lamps, light fixtures, and light bulbs in an area at once. This technique will save on labor costs for any special installation and making these changes all at once keeps illumination at a constant level and avoids stressing out a system with dying lamps. Newer light fixtures are designed to push light out into the room to insure that all of the light produced by a lamp is used, whereas older light fixtures were not similarly designed for maximum efficiency.
- When installing new lighting systems think about the areas that require additional lighting. Providing spot lighting for areas that have a high work load can reduce the need to over-light an entire area unnecessarily.[7]
- Remember to consider lumens generated when making lighting replacements. While certain efficient lighting upgrades may replace standard incandescent bulbs, they may not provide the same amount of lumens (light produced). Be sure you replace a bulb with sufficient lumen production to make your lighting situation satisfactory.
- A large portion (about 30% or more) of the light from a typical yard light never makes it to the intended target.[8] Installing a fixture on your outdoor lamp that directs light to the desired area can allow for a lamp to be installed that uses less wattage, thereby saving energy.[9]

[5] See: http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014710. See also:http://www.uwex.edu/energy/lighting.html.
[6] Energy Efficiency and Renewable Energy, Energy Savers: Lighting Maintenance. U.S. Department of Energy, Retrieved at: http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12270.
[7] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al. Retrieved at: http://www.ag.ndsu.edu/pubs/ageng/structu/ae1366.pdf.
[8] Outdoor Lighting., Scott Sanford. Retrieved At: http://www.uwex.edu/energy/lighting_OL.html.
[9] Energy Efficient Agricultural Lighting., Scott Sanford. Retrieved at: http://www.mainerural.org/energy/fieldguide/efficientlighting.pdf.

Lighting Technology Upgrades

Energy Efficient Lamp/Bulb Technology

While it's impossible to predict the various lighting needs of each individual farmer that reads this publication, an education on the various types of lighting can help all farmers determine whether their lighting systems are as efficient as they could be. This section provides an overview of the various energy efficient lighting options available, along with their potential gains in energy efficiency.

At some point, every operation will need to replace both incandescent lighting fixtures and incandescent light bulbs with more energy efficient florescent light bulbs. A typical incandescent light bulb uses only a small portion of the supplied energy for light; the rest escapes as heat. This lighting option also has a very short life span of only 2,000 hours when compared to other lighting options such as compact florescent light bulbs (CFLs), which have a life span around 20,000 hours.[10] Energy savings can cover the initial costs of this replacement in 1-3 years.

Compact Fluorescent Lights (CFLs)

- The most commonly used energy efficient light bulb, CFLs use a quarter of the energy incandescent light bulbs do and last 8 to 10 times longer. CFLs reduce energy use by 75% per light which could save you $20 per light per year.[11]
- While there used to be some problem with CFLs lighting properly at cold temperatures, the newest models can start at temperatures around -20 degrees Fahrenheit.[12]
- Refrain from using CFLs in dimmable switches unless they are specifically rated as such. Cold cathode CFLs provide the best dimmable capability.

T-8 Lamps

- Modern lamps, called T-8 lamps, are the highest efficiency lamps for 4 and 8-foot fixtures, replacing older fluorescent models.[13]
- If the fluorescent tubes in your barns and work areas are more than 12 years old, it would be a good idea to switch them out for modern T8 lamps. T8 models reduce energy consumptions by at least 20%.
- Adding an electronic ballast (used to regulate the electrical load) to a system with T8 lamps can save an additional 7 to 10 percent on the cost of lighting.[14, 15, 16] Electronic ballasts eliminate flicker, are more energy efficient, produce less heat, last longer, and start up at cooler temperatures.[17]

[10] Energy Efficient Poultry Lighting Factsheet. Ontario Ministry of Agriculture, Food, and Rural Affairs. (2006). Retrieved at: http://www.omafra.gov.on.ca/english/engineer/facts/06-009.htm.
[11] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy. Retrieved at: http://www.xcelenergy.com/SiteCollectionDocuments/docs/frameset-ca-dairy-farms.htm; Conservation Practices That Save., NRCS (2006). Retrieved at: http://www.mainerural.org/energy/fieldguide/confinedanimal.pdf.
[12] Fluorescent Lamps, Scott Sanford. Retrieved at: http://www.uwex.edu/energy/lighting_fluoro.html.
[13] Fluorescent Lamps, Scott Sanford.
[14] Dairy Farms: Energy Saving Ideas. Efficiency Maine. (2005) Retrieved At: http://www.mainerural.org/energy/fieldguide/dairychecklist.pdf.
[15] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[16] Energy Efficient Lighting. CET Online. Retrieved At: http://cetonline.org/Home/CFL.php.
[17] Dairy Farm Energy Management Handbook. Karl Ohm, Rural Energy Management Council. Retrieved at: http://datcp.state.wi.us/fs/environment/dfeh/pdf/dfemh.pdf.

High Intensity Discharge Lighting

- High Intensity Discharge lighting includes Metal Halide (*pictured*), High Pressure Sodium, Mercury Vapor, and Low Pressure Sodium lamps.
- Metal halide lamps are commonly found in free stall barns and shops with higher ceiling heights, among other farm uses.
- Larger incandescent fixtures, such as pole lights or floodlights, should be replaced with more efficient lights such as metal halide lamps. These are designed specifically to cast a big pool of light over a wide area but with significantly less energy consumption.
- Replace probe-start (standard) metal halide lamps with pulse-start metal halide lamps or high pressure sodium lamps.[18] Replacing standard metal halide lamps with pulse-start metal halide lamps can decrease energy use by 10%.[19] Metal halide lamps also have an increased lamp life and light output.
- Metal halide lamps have better color rendering than high pressure sodium lamps, which make things appear yellow. Keep this in mind when deciding what type of lamp you should use in replacing outdated lights.
- Security yard lighting historically has used mercury vapor lights, however there are many newer and more efficient options that 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. The increased energy production will allow you to install bulbs that draw on fewer watts, saving you money on energy costs.

Lighting Energy Calculator

This calculator can help show potential energy savings gained from efficient lighting methods:

- http://www.ruralenergy.wisc.edu/conservation/lighting/default_lighting.aspx

LED Lighting

LED light bulbs are even more energy efficient than CFLs but until very recently were much too costly to be considered an option for commercial or residential use.[20] They are extremely energy efficient, using only 2-10 watts of electricity (approximately 1/3 less than a CFL). They also don't contain mercury, which means they don't require special disposal. LED lights are solid; they do not work by a filament, making them more resistant to shattering and breaking. New advances in the technology are making them easier to produce, but they are still a fairly expensive option. Stay in contact with your lighting supplier as this technology continues to develop.

Lighting Timers/Motion Sensors

In addition to efficient lights and fixtures, timers and motion sensors can also contribute to an energy efficient lighting system on your farm. Motion sensors can be used to turn lights on in areas when someone enters the room or when motion occurs outdoors. They then turn the lights off after a period of time when no motion is sensed, eliminating unnecessary electrical usage.[21] Timers ensure that your lights will be turned off during hours when they're not needed. Compared to the amount of energy they can save, timers and sensors are relatively inexpensive, and can be found for $50-$200. All farmers considering lighting system upgrades should certainly include timers and/or motion sensors in their upgrade plans.

[18] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[19] Energy Efficient Agricultural Lighting., Scott Sanford., Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[20] LED Lighting. Retrieved at: http://eartheasy.com/live_energyeff_lighting.htm.
[21] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.

Chapter 2: Pump and Motor Systems

All farms utilize pumps and motors, for activities such as moving water, grain, waste, or milk, air circulation, running feeders,[22] or any other number of farm related jobs. Nationally, motors on farms account for approximately 18% of farm energy use.[23] Large energy use of motors on farms means there is a lot of opportunity for energy savings; implementing cost-saving techniques and technologies can save a farm 30% of its motor related energy costs. This chapter details the changes a farmer can make to increase the energy efficiency of their pumps and motors.

Preventative Maintenance: Pumps and Motors

Hard working motors and pumps around the farm often receive very little attention until there is a problem. However, while motors and pumps might be operating fine, they may not be working at full energy efficiency potential. Simple maintenance measures can ensure they continue to run efficiently. For every dollar spent on maintenance, you will save five in other expenses. Remember, just because a piece of machinery is running, it doesn't mean that it is running as well as it could.[24]

- Watch for belts that are too tight, too loose, or not aligned. A worn belt can cause a machine to work harder and run slower. Energy efficiency in these situations can drop by up to 20%.[25] Replace pump and fan belts with cogged V belts. These belts grip better, resulting in reduced slippage and a 2-5% energy savings. Additionally, poorly sized belts can reduce belt lifespan by as much as 50%.[26]
- Install an appropriately sized pump or motor. Oftentimes motors are oversized, meaning they run below the full-load efficiency stated on the nameplate.[27] Motors should operate at a load between 65% and 100%. A motor too large for its job, operating at a low load percentage, is less efficient than a motor sized to match the load required.[28] Similarly, an installed pump that is too large for your system will cause unnecessary wear and tear on your system.
- Use totally enclosed motors for all farm applications in order to prevent excess dirt and dust from entering the motor.
- Maintain your pump system for maximum efficiency. Common maintenance tasks on pumps include: bearing lubrication and replacement, mechanical seal replacement, wear ring adjustment or replacement, impeller replacement, and pump/motor alignment.[29]
- At a minimum, it's a good idea to check all of the motors and pumps at least twice a year. However, older motors and pumps and those that require more care should be checked at least once every two months.[30]

Utility Rebates!

Motors and Pumps

Average Utility Rebates for Motor and Pump Improvement:

- Utilities generally reimburse consumers for various sized motors based on a per horsepower basis
- Utilities will also generally consider what type of motor is being replaced, if any, and what the change in motor efficiency might be.
- High efficiency electric motor rebates:
  - New ~ $5.00/hp.
  - Replacement/retrofit: ~ $20/hp.
- Variable Speed Drive rebates: ~$35/hp.

[22] Conservation in confined animal operations

[23] Energy Efficiency and Farm Equipment., Institute for Energy and the Environment. Retrieved at: http://www.agenergysolutions.org/site/index.php?page_id=178.

[24] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy; Farm Energy Management Handbook. Karl Ohm, Rural Energy Management Council.

[25] USDA-NRCS. Conservation Practices that Save: Energy Conservation in Confined Animal Operations. June 2006.

[26] Dairy Farm Energy Management Handbook. Karl Ohm, Rural Energy Management Council.

[27] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.

[28] Energy Efficiency of Electric Motors on the Farm., Cole Gustafson, Carl Pedersen, NDSU. (2010). Retrieved at: http://www.extension.org/pages/Energy_Efficiency_of_Electric_Motors_on_the_Farm.

[29] U.S. Department of Energy. Energy Efficiency and Renewable Energy. Industrial Technologies Program. Improving Pump System Performance: A sourcebook for Industry. May 2006.

[30] For more very detailed information on motors and pumps, including maintenance, installation, repair and replacement, see the Department of Energy's "Improving System Performance" Guides on Motors and Pumps, respectively. These documents, while not tailored specifically to farm operations, have extensive advice for those looking for more in depth information. The documents can be retrieved at: http://www1.eere.energy.gov/industry/bestpractices/techpubs_motors.html.

Motor and Pump Technology Upgrades

High Efficiency Electric Motors

Once you've made a decision to replace your older, less efficient, motor you'll next need to decide the best option for replacement. It's likely a high efficiency electric motor will be your most cost effective option. Compared to a standard efficiency motor, high efficiency electric motors can reduce energy use by 3-8%. The higher initial purchase price of a high efficiency electric motor is small compared to the savings a farmer will realize over the motor's lifetime (as little as 3-5% of its total life-cycle cost[31]). As evidenced by the diagram below, the more efficient the motor, the lower the annual running cost of the motor. These costs savings will aid a farmer in recouping the initial costs of a high efficiency electric motor in as little as a year or two.

Annual Electricity Costs for Continuous Operation of a 1 hp Motor at Full Load[32]

Motor Efficiency %	Electricity Costs							
	$0.06	$0.08	$0.10	$0.12	$0.14	$0.16	$0.18	$0.20
76	$516	$688	$860	$1,032	$1,204	$1,376	$1,548	$1,720
78	503	670	838	1,005	1,173	1,341	1,508	1,676
80	490	653	817	980	1,144	1,307	1,470	1,632
82	478	638	797	956	1,116	1,275	1,435	1,594
84	467	622	778	934	1,089	1,245	1,400	1,556
86	456	608	760	912	1,064	1,216	1,368	1,520
88	446	594	743	891	1,040	1,188	1,337	1,485
90	436	581	726	871	1,017	1,162	1,307	1,452
92	426	568	710	852	994	1,137	1,279	1,421
94	417	556	695	834	973	1,112	1,251	1,390
96	408	545	681	817	953	1,089	1,225	1,361

- However, keep the above information in perspective. Many of your farm motor applications won't be used continuously for an entire year. If a motor is used much less often, it won't likely achieve the same type of immediate payback.
- High Efficiency Electric Motors are particularly effective when the motor is run at least a third of the time, and when the cost of electricity exceeds $0.07 per kWh.[33]
- Use a Nominal Efficiency rating when comparing electric motors. Apparent, Calculated, and Minimum Guaranteed Efficiency ratings are less accurate for these types of analyses.

[31] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[32] Coping with High Energy Prices: Select Energy Efficient Motors., PSU College of Agricultural Sciences Cooperative Extension. (2009). Retrieved at: http://energy.cas.psu.edu/motors.html.
[33] Dairy Farm Energy Management Handbook.

Replace or Repair?

Notwithstanding all possible preventative maintenance, a farmer will eventually have to decide whether or not it is more efficient and economical to replace a motor instead of repairing it. Here are some reasons why the former may be the better option for you[34]:

- Repairing a motor often decreases its efficiency by at least 2%.
- Oftentimes motors are incorrectly sized in relation to the task. Replacing a broken motor with a new, and more appropriately sized, motor will increase efficiency.
- Expected lifetime of the repaired motor may not be more cost efficient than replacement with a new motor.

On the other hand, repair may be better than replacement if[35]:

- The motor in question runs only a few hours a year.
- The particular motor is designed specifically for the task and is difficult to replace.
- The repair shop can guarantee the repaired motor will not decrease in efficiency.

Variable Speed Drives

Variable-Speed Drives (VSDs) have recently become one of the largest and easiest ways to realize significant energy savings with your pump and motor systems. VSDs, also known as Variable Frequency Drives (VFDs) or adjustable speed drives (ASDs), match the speed of the pump or motor to workload needed. Traditional drives run at the highest speed that may be needed for the operation.[36] If the need is lower than what the pump is running at, the excess energy is wasted. VSDs control the speed of the pump or motor so that it matches the current requirements of the load, saving energy.[37]

- Adding a VSD to your pump or motor can reduce energy expenditure at least 50%, and oftentimes more.[38]
- The initial cost of installing VSDs can be made up within one to three years.[39]

Motor and Pump Energy Assessment Tools

This assessment tool gives specific examples of the monetary benefit of replacing an old motor with an energy efficient motor:

- http://energy.cas.psu.edu/motors.html

This efficiency tool helps inform your process of whether you should invest in a variable speed drive for your motor:

- http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014896

Finally, Appendix B of the Department of Energy's "Improving Pump System Performance" contains a useful self assessment tool to use in judging whether your pump system is correctly sized.[40]

[34] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[35] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[36] Energy Efficiency of Electric Motors on the Farm., Cole Gustafson, Carl Pedersen, NDSU. (2010).
[37] Conservation Practices That Save., NRCS (2006).; Energy Efficiency and Farm Equipment., Institute for Energy and the Environment.; Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[38] The Farmer's Handbook for Energy Self-Reliance., Institute for Energy and Environment. (2007).; Dairy Farms: Energy Saving Ideas. Efficiency Maine.
[39] Minnesota Farm Incentives. Alliant Energy. (2010). Retrieved at: http://www.alliantenergy.com/UtilityServices/ForYourFarm/RewardsFinancing/014704; Dairy Farm Energy Management Guide. Retrieved at: http://www.sce.com/NR/rdonlyres/6CFAA95A-1660-432C-B46B-E51D246263C4/0/Dairy_Farm_Milk_Harvest.pdf; Vacuum Pump Variable Speed Drives. Adam Holmes, EnSave, Inc., Retrieved at: http://www.mainerural.org/energy/fieldguide/estimatesvacuumpump.pdf.
[40] See: http://www1.eere.energy.gov/industry/bestpractices/techpubs_motors.html.

Chapter 3: HVAC

While the uniqueness of each individual farm operation prevents many general statistics, Heating, Ventilation, and Air Conditioning (HVAC) systems generally contribute 40-60% of energy expenditures in commercial and residential buildings in the U.S.[41] There are many ways to cut down on energy use in this area, however. This chapter addresses common issues in HVAC systems on farms, how to improve your farm's HVAC energy consumption, and how improvements can save you money on your bottom line.

Preventative Maintenance/Low Cost Improvements for HVAC Systems

Keeping up a regular maintenance schedule ensures that your HVAC systems are running correctly and efficiently, saving you money. Because of the dirt and grime contained in the large amounts of air moved through HVAC systems, preventative maintenance is especially important to this area of technology. While it may not be as flashy as installing new equipment, keeping your HVAC systems running at peak efficiency will save you significant costs on your energy bill.

- Loose fan belts can reduce fan output by 30%. If possible, make sure your fans contain automatic belt tensioning devices. This will help to ensure the fans run efficiently, without having to constantly inspect them.
- Make sure fan shutters are unencumbered and remain clean.[42] Effective shutters on fans cut energy consumption 10-20%.[43] However, make sure shutters are closed completely when a fan or ventilation system is not operating. A single shutter which does not fully close can cost $200 a year in lost heating costs.[44]
- Additionally, make sure to clean guards and shutters regularly. Dirty shutters may reduce fan output by as much as 40%.[45]
    - Not only are fans and shutters keys to good ventilation, but a poorly maintained ventilation system can be 30-50% less energy efficient.[46]
- Clean all surfaces of fans to reduce drag and maintain efficiency. Unclean fans can reduce airflow capacity by 30%.[47]
- Trim vegetation growing near fans, so as not to impede the air flow of the fan.[48]
- Use natural ventilation when possible. Natural ventilation, where wind moves air through buildings, is the most energy efficient ventilation system. Open side-curtain walls or other doors and windows when weather permits. A day or two of free ventilation can have a significant effect on your energy consumption for the month.[49]

Utility Rebates!

HVAC

Average utility rebates for HVAC improvements:

- Programmable Thermostat Rebates: Up to 50% cost share.
- Ventilation Improvements: Up to 50% cost share
- Energy Efficient Fans: $45-150 per fan based on fan size (14"- 48")
- High Volume Low Speed Fans: ~$450 per fan

[41] The Farmer's Handbook for Energy Self-Reliance., The Institute for Energy and Environment, p. 16. (2007).
[42] Coping with High Energy Prices: Ventilation., PSU College of Agricultural Sciences Cooperative Extension., Retrieved at: http://energy.cas.psu.edu/360.htm.
[43] Some Fans Can Be Energy Hogs. Retrieved at: http://www.mainerural.org/energy/fieldguide/fanventilation.pdf.
[44] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection. Retrieved at: http://datcp.state.wi.us/fs/environment/dfeh/equip_operation_maintenance.jsp.
[45] Wisconsin Energy Efficiency and Renewable Energy Resource: Dairy. Scott Sanford, UW Extension., Retrieved at: http://www.uwex.edu/energy/dairy_V.html.
[46] Coping with High Energy Prices: Ventilation., PSU College of Agricultural Sciences Cooperative Extension.
[47] Conservation Practices That Save., NRCS (2006).
[48] Coping with High Energy Prices: Ventilation., PSU College of Agricultural Sciences Cooperative Extension.
[49] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.

HVAC Technology Upgrades

Ventilation

Proper ventilation is important to bring oxygen to livestock, remove dust and moisture, and cool livestock during a warm season. However, if not properly designed and maintained they can quickly consume vast amounts of energy in their operation. The first step to improving your ventilation system's energy efficiency is to estimate the efficiency of your current fans, which can be done with performance ratings. Modern, aerodynamic fans move air more efficiently; thereby saving you energy and money.[50] Here are some tips for choosing the best, and most energy efficient, fans for your farm.

- Install energy efficient high speed fans. Replace high speed fans with Energy Efficient High Speed Fans. Look for fans with an efficiency rating of at least 21 cubic feet per minute per watt (or air moved per energy consumed at a specific static pressure), for a 48" exhaust fan.[51] Although the initial cost of the fan may be greater, the energy saved over the lifetime of the fan may be in the thousands of dollars, and the initial cost of the fan may be recovered within a year due to energy savings.[52]
- Choose the correct fan size. Large diameter fans are more energy efficient than small diameter fans (large diameter fans move a greater amount of air per unit of energy). However, fans should not be larger than required, a mistake which would cause energy to be used unnecessarily.[53]
- High Volume Low Speed (HVLS) fans. HVLS fans are large paddle fans ranging in size all the way up to 24 feet in diameter. These fans move 5 to 10 times more air[54] than traditional high speed fans, and use about the same amount of energy. HVLS fans maintain airflow throughout the enclosure while keeping pests like birds and insects away from livestock.[55] These fans provide extensive air circulation while using less energy and creating less noise. They are generally recommended for loose housing applications with high walls.[56]

Insulation

Insulation is a key component to conserving heat in the winter and keeping heat out during warmer months.[57] Insulation hinders stray heat flow, thereby saving energy and money. With the importance of regulating temperature for most livestock operations, insulation can play a big part in keeping your buildings at a consistent temperature.

[50] Some Fans Can Be Energy Hogs.
[51] Ventilation Self Assessment., USDA NRCS. Retrieved at: http://www.ruralenergy.wisc.edu/conservation/ventilation/default_ventilation.aspx.
[52] Fan Performance and Efficiency for Animal Ventilation Systems., Larry Jacobson and John Chastain, University of Minnesota Extension., http://www.extension.umn.edu/distribution/livestocksystems/DI0956.html; Some Fans Can Be Energy Hogs.
[53] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[54] HVLS fans can move anywhere from 150,000 – 300,000 cfm compared to traditional fans that move about 30,000 cfm, both using the same approximate amount of energy.
[55] Minnesota Farm Incentives. Alliant Energy. (2010).
[56] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[57] Farmstead Energy Audit., NDSU Extension Service. Carl Pederson, et. al.; Insulation Know How., John Bartok, Jr. and John Grubinger. (2010). Retrieved at: http://www.extension.org/pages/Insulation_Know-How; Efficient Agricultural Buildings: An Overview., Tracy Mumma; NCAT. (2002). Retrieved at: http://attra.ncat.org/attra-pub/agbuildings.html#Energy.

IMPROVING EFFICIENCY THROUGH COMMON FARM APPLICATIONS

The Department of Energy estimates that inadequate insulation in the floors, walls or ceilings of older buildings amounts to nearly one-third of air leakage, while ducts, heat sources and plumbing add up to nearly 45%.[58] If insulation is more than 20 years old, it should almost certainly be replaced, as advances in insulation since that time will provide greater energy savings and a timely return on investment.

R-Value The primary standard used for judging insulation quality is a term called "R-Value." R-Value is a measure based on the insulation's material and thickness. The higher the R-value, the more effective the insulation is at trapping heat.[59]

Insulation experts recommend R-Values for farm buildings in northern states at R-40 for ceilings and R-20 for walls. While the experts encourage farmers to keep costs of materials, installation, and equipment in mind, they also note that payback on energy saved from increasing your insulation to these standards is usually less than 3 years.[60]

- When insulation is compressed or damaged, the R-value will decrease, as the insulation is not able to provide a buffer between zones as effectively. Water damage, animals and insects can contribute to damaged insulation and make it less effective at maintaining heating and cooling in your building.

HVAC Energy Efficiency Tools

This online ventilation self-assessment tool allows you to quickly assess your current ventilation equipment, so you can judge whether upgrading to efficient fans and ventilation units on your farm is right for you:

- http://www.ruralenergy.wisc.edu/conservation/ventilation/default_ventilation.aspx

This website will help a farmer to estimate the efficiency of her or his current ventilation fan:

- http://www.mainerural.org/energy/fieldguide/fanefficiency.pdf

Finally, this simple online calculator can help you determine the value of installing high efficiency fans on your existing operation:

- http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/01489

Other Insulation Tips

- Caulking and weather stripping around windows and doors can reduce heat loss up to 37% in those areas.[61] Caulk is an inexpensive fix to stopping air leaks and some types of caulk can last up to 20 years. Caulk can also be used to stop leaks in the walls of foundations and in corners of buildings.[62]
- Finally, a popular tip recommended by most all utilities is to insulate your water heater. By wrapping your water heater in an inexpensive insulated blanket, you are ensuring that heat and energy are trapped by the insulation. Pre-cut blankets, of R-8 value or greater, can be found at your local hardware store.

[58] The Easiest Way to Save 10% on Energy Bills. Dan Shapely; The Daily Green. (2009). Retrieved at: http://www.thedailygreen.com/environmental-news/latest/weatherization-drafts-47111201.
[59] Insulation Know How., Bartok, Jr. and Grubinger. (2010).
[60] Insulation Know How., Bartok, Jr. and Grubinger. (2010).
[61] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[62] Weatherization 5- Caulking to Reduce Energy. Retrieved at: http://www.doityourself.com/stry/weatherizecaulking.

SECTION III

Farm Specific Efficiency Improvements

This section of the best practices guide will address energy efficiency issues unique to specific types of farm operations. Some types of operations are more energy intensive than others, and have received proportionately more attention in the research and development of energy efficient practices. Dairy operations, grain drying, and irrigation are very energy intensive processes, and researchers have devoted significant resources to make these applications more energy efficient.

On the other hand, beef, pork and poultry operations are less energy intensive and primarily deal with issues of lighting and building temperature regulation. Since these subjects have been touched on previously, these sections will contain significantly less information, but will still contain some industry specific tips for keeping your respective farm in an energy efficient position.

Chapter 1: Cash Crop Operations

Cash crop operations consist of two primary energy intensive practices: grain storage/drying and irrigation. Thus, this section will focus mainly on these two most common crop raising activities. While these activities may span many types of growing operations, the best practices should apply for nearly all farmers.

Field Management Energy Use?

One topic of discussion noticeably absent from this publication is a discussion of in-field energy use. The discussion of topics like fuel costs, reducing trips through the field, and soil management certainly figure into more broad energy use issues, but did not fit the primary focus of this document – electric, propane, and natural gas use. Still, for parties interested in learning more about this area, a few good places to start include:

- http://attra.ncat.org/attra-pub/consfuelfarm.html
- http://attra.ncat.org/attra-pub/croppingsystems.html
- http://tractortestlab.unl.edu/testreports.htm

Utility Rebates!

Irrigation

- Irrigation systems can benefit from pump and motor rebates discussed in previous sections. In addition some utilities help upgrade irrigation systems based on a per acre basis. One utility surveyed offered irrigation upgrade assistance at the rate of $20 per irrigated acre.

IRRIGATION

Irrigation requires significant energy[63] and water use. However, decisions to scrimp on energy and water inputs that directly relate to ultimate crop production makes energy efficiency in irrigation a low priority for many farmers. As a result, irrigation systems on average use about 40% more fuel than if they were correctly sized and maintained, and 25% of motor energy is wasted because of poor efficiency.[64] Implementing energy efficient irrigation systems limit energy use and reduce water use, while still maintaining high field production. The resulting energy savings come as an added bonus to these improved, workable irrigation systems.[65]

Preventative Maintenance/Low Cost Improvements for Irrigation Systems

- Consider all relevant motor maintenance considerations discussed earlier in this publication. In addition, make sure pipelines aren't leaking, screens are cleared, and pumps are properly greased and lubricated. Irrigation maintenance is often out of sight, out of mind, but irrigation systems in disrepair can waste huge amounts of water and energy.
  - For an in depth, technical look at maintaining and improving irrigation pump system performance check out ATTRA's "Energy Saving Tips for Irrigators."[66] That document provides great advice on keeping irrigation systems running smoothly and efficiently, at a level of detail not appropriate for this publication.

[63] Efficient Irrigation Planning: Factors to Consider., Larry Curtis and Ted Tyson; Alabama Cooperative Extension., Retrieved at: http://www.aces.edu/anr/irrigation/ANR-545.php.
[64] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006). Retrieved at: http://attra.ncat.org/attrapub/PDF/energytips_irrig.pdf.
[65] Introduction to Energy Efficient Irrigation., Mike Morris and Vern Grubinger. (2010). Retrieved at: http://www.extension.org/pages/Introduction_to_Energy_Efficient_Irrigation.
[66] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).

- Improve irrigation scheduling. Irrigation scheduling is important to avoid over-watering or under-watering crops.[67] Many farmers schedule irrigation based on the calendar, not their particular crop needs. Irrigation should be based on evaporation and uptake, and only used when water is needed.[68]
  - Proper scheduling makes sure you are watering your crops at the right times, and can reduce energy used for irrigation by 30%.[69]
- Improve your irrigation management techniques. Getting into good management habits will result in energy savings.
  - Use mulches and cover crops to increase the water-holding capacity of the soil[70] and plant wind breaks to decrease evaporation.[71]
  - Understand your system's net water application rate and check soil moisture levels throughout the season to ensure optimum irrigation efficiency.[72]
  - Reduce horsepower needed by taking into account natural elevation drops and the force of gravity from your irrigation systems.[73]
  - If off-peak irrigation pumping rates are available from your energy provider and appropriate for your crops, consider irrigating during off-peak hours to save money.[74]
- Follow up on improvements. After making technological improvements to your irrigation system, adjust your irrigating time to reflect your efficiency gains. Improving your system will lead to better water application, meaning less time spent irrigating and higher energy savings.[75]
  - Remember, mechanical improvements will not reduce energy use and costs unless the irrigator reduces the amount of time the system is in use.[76]

Irrigation System Technology Upgrades

A number of energy efficient improvements are available to operators looking to save money on their irrigation systems. In addition to providing significant energy savings, many of the following suggested improvements will also result in increased moisture application to crops and less wasted water due to runoff or wind drift.

[67] Irrigation Scheduling Made Easy. LSU Ag Center., Retrieved at: http://www.lsuagcenter.com/NR/rdonlyres/CC0C6460-3875-47C1-937D-4A695A22AC1D/51992/pub3070irrigationschedulingHIGHRES.pdf.
[68] Irrigation Scheduling Made Easy. LSU Ag Center.
[69] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.; Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[70] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[71] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[72] Introduction to Energy Efficient Irrigation., Mike Morris and Vern Grubinger. (2010).
[73] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[74] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[75] Introduction to Energy Efficient Irrigation., Mike Morris and Vern Grubinger. (2010).
[76] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).

Irrigation Energy Assessment Tools

Use these websites to measure the amount of energy and water your irrigation system uses, and receive specific advice on how to improve its efficiency.

The irrigation self assessment tool helps identify ways to reduce energy use with any of the major irrigation systems: center pivot, linear move, hand move, solid set, side roll, flood, and drop trickle:

- http://www.ruralenergy.wisc.edu/conservation/irrigation/default_irrigation.aspx

The irrigation energy estimator will help you understand the costs involved in your irrigation system and explain techniques that may help you manage your irrigation system more effectively:

- http://ipat.sc.egov.usda.gov/

For a helpful tool to aid in irrigation scheduling see:

- http://www.lsuagcenter.com/NR/rdonlyres/CC0C6460-3875-47C1-937D-4A695A22AC1D/51992/pub3070irrigationschedulingHIGHRES.pdf

Alliant Energy provides a very simple tool to help you calculate savings gained from installing a pressure irrigation system that uses 50% less water pressure:

- http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014902

Low Pressure Nozzles

Low pressure improvements spread water over crops and soil using low psi nozzles (anywhere from 10 to 45 psi) and drop tubes. Low pressure systems allow irrigation setups to use smaller pumps for distributing the same amount of water across the field, which allows the implementation of a smaller, more efficient pump or motor.

- Low pressure nozzle systems replace a few, high pressure nozzles across the irrigation boom with more frequent, smaller nozzles across the same span.
- Drop tubes can be installed to move the low pressure nozzles closer to the crop, which helps decrease wind drift and places the water source nearer the application point.
- Regardless of the type of nozzles employed, sprinkler nozzles should be replaced at least every seven years. Good working sprinkler nozzles ensure uniform water application and energy efficiency related to water pumping. One study estimated farmers lose $4.00 per nozzle in energy costs alone when nozzles aren't functioning properly.[77]

Upgraded Sprinkler Systems

In addition to low pressure nozzle systems, sprinkler systems can also be modified to more evenly distribute water and save unneeded extra irrigation costs.

- Spinners can create larger droplets and reduce wind drift, increasing efficiency of the irrigation system.[78]
- Converting from low-angle impact sprinklers to spray heads improves efficiency by 5%.

Low Energy Precision Application (LEPA) Systems

LEPA systems install hoses or drag socks on the end of drop tubes and apply water directly to crops and soil directly at ground level. LEPA systems deposit water at the surface of the soil, thereby reducing wind drift and creating a 98% application efficiency.[79]

- Though these systems don't work for all conventional crops, energy savings can be as great as 40%, with a payback under 4 years.[80]
- LEPA systems also reduce irrigator induced wheel ruts, because water is applied behind the pivot rotation track.

[77] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[78] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).
[79] Water Loss from Above Canopy and In-Canopy Sprinklers., Yontz, Kranz, and Martin, University of Nebraska-Lincoln. Retrieved at: http://www.ianrpubs.unl.edu/epublic/pages/publicationD.jsp?publicationId=184.
[80] Energy Saving Tips for Irrigators., Mike Morris and Vicki Lynne; NCAT. (2006).

GRAIN DRYING

After crops have been raised and harvested the next energy intensive farm application begins. Grain drying is a yearly chore for most farmers and is a very energy intensive farm application. Every year, farmers work to find the right balance between minimizing expensive grain drying and keeping crops at an optimum moisture and temperature level. With the rising costs of fossil fuels, improving energy efficiency in the grain drying arena can mean significant savings for farmers.[81] Alternatives to typical hot-air drying, combined with proper equipment maintenance, can help a farmer reduce his or her energy costs in relation to grain drying.[82]

Preventative Maintenance/Low Cost Improvements to Grain Drying Operations

- Avoid over drying. Over drying is expensive for three reasons: increased fuel use, reduction in the number of bushels that can be dried per day, and reduced number of bushels for sale.[83] Ensure your moisture meter for testing grain is accurate so you'll be making the right decisions on when to begin and end your grain drying.
- Clean your grain before drying. Remove broken kernels and weed seeds; they cost extra money to dry and they reduce dryer airflow.[84]
- Level the grain in your bins and dryers. Keep grain levels even throughout your bins. This practice promotes uniform drying which is much more efficient and prevents grain loss due to spoilage.[85]
- If possible 'dry' your grain while it is still in the field.[86] While considerations like weather, work time, grain quality, and potential disease need to be kept in mind, allowing crops to dry while still in the field can greatly reduce, or eliminate the need for, mechanical grain drying.
- Clean the aeration enclosure under the floor of a grain bin to lesson the resistance for the fan. Close up holes and leaks that can allow air to escape, clean inlet screens, and time aeration to the weather and time of day for maximum cooling.[87]

Grain Drying Techniques

The following discussion focuses on grain drying techniques that can reduce energy use while still ensuring the quality of the farmer's production. While the discussion is by no means exhaustive, it has compiled some of the most prevalent techniques being practiced throughout the Midwest.

[81] Energy-Efficient Grain Drying Resources., Schahczenski, Adam, and Morris; NCAT. (2009). Retrieved at: http://attra.ncat.org/attra-pub/graindrying.html#goals.
[82] Energy-Efficient Grain Drying Resources., Schahczenski, Adam, and Morris; NCAT. (2009).
[83] Grain Dryers., Alliant Energy. Retrieved at: http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014707.
[84] Natural Air Grain Drying., Saskatchewan Agriculture. (2008). Retrieved at: http://www.agriculture.gov.sk.ca/Default.aspx?DN=bc37685d-2d4a-414e-99e3-f76833d48e2b.
[85] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[86] Grain Dryers., Alliant Energy.
[87] Reduce Energy Costs in Agriculture., Mississippi State University Extension.

FARM SPECIFIC EFFICIENCY IMPROVEMENTS

As an added introduction, the most popular and conventional type of continuous flow grain dryer is the cross flow model. However, farmers should consider concurrent flow, counter flow, or mixed flow dryers in place of more conventional cross flow dryers when making upgrades or replacement decisions. Each of these technologies can be up to 40% more energy efficient than cross flow technology.[88]

- Vacuum cooling and heat recovery systems, mentioned in other areas of this document, can increase the efficiency of continuous-flow dryers by 20%.[89]

In-storage drying

Conventional grain drying usually involves drying grains at high temperatures in a continuous flow dryer and then quickly cooling the grain in the same dryer. However, grain can also be cooled in storage bins with aeration fans.

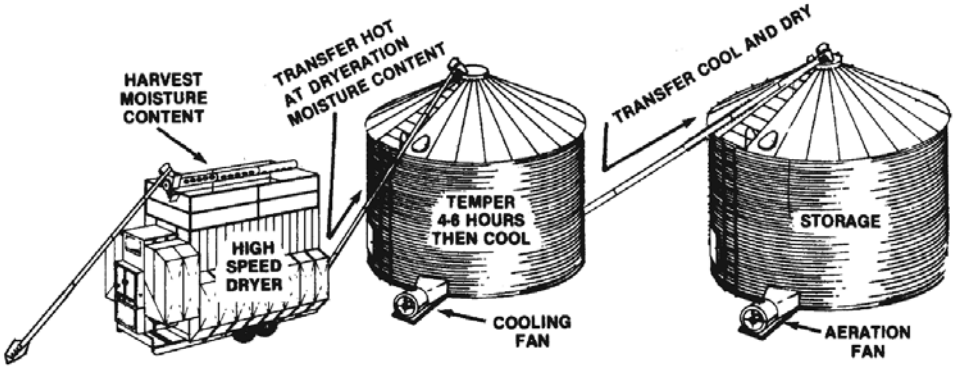
Using in-storage drying, drying begins in a conventional high temperature grain dryer. After grain reaches a moisture level 1-2 percentage points above the target level the grain is moved from the dryer to a storage bin while it is still hot, and then exposed to the bin's aeration fans, the grains will typically lose an additional 1 to 2 percentage points of moisture through the process.

Thus if a farmer hopes to store his grain at 14-15%, he can move the grain from the dryer when it is at the 16-17% moisture level. The extra moisture loss resulting from cooling in the storage bin allows farmers to use energy intensive high temperature grain dryers less, saving the farmer money on fuel,[90] not too mention freeing up their grain dryer for additional crops.

Dryeration

Dryeration takes the in-storage drying method one step further to increase moisture loss and avoid condensation issues. Using dryeration, still-hot grain coming from a high temperature grain dryer is moved to another 'cooling bin', where it is steeped for 4-12 hours. During this cooling process the grain can lose up to an additional 3% of moisture. By cutting down on the use of the high temperature grain dryer for this 3% farmers can save as much as much as 25% on their grain drying energy costs.[91] The schematic below lays out the dryeration process nicely.

Schematic of Dryeration System[92]



[88] Grain Drying, Scott Sanford. Retrieved at: http://www.uwex.edu/energy/d_BD.html.
[89] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[90] Grain Dryers., Alliant Energy.
[91] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[92] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.

Natural Air Drying

Using Natural Air Drying, grain is dried using large fans blowing air through mesh drying floors in storage bins.[93] While natural air grain drying takes longer than other conventional drying methods, it is more energy efficient if operated correctly.[94]

- Natural Air Drying works best when grain is cleaned and grain enters the bin with moisture levels around 20-22%.[95]
- Wheat dries most efficiently using the natural air drying method at depths less than 18 feet, and corn dries best at depths no greater than 22 feet. These prescribed depths limit airflow resistance, allowing air to continuously move through the crop.
- Drying corn using natural air drying methods does not use any fuel, but does use one kilowatt-hour of electricity per bushel to operate the fan.[96]
- Natural Air Drying does rely on ambient air temperatures and humidity levels, and takes longer than conventional drying. But for farmers with sufficient storage space and appropriate weather conditions this method can be used effectively to significantly reduce grain drying costs.

Energy Calculators and Audits

Energy Efficient Grain drying questionnaire:

- http://www.extension.purdue.edu/renewable-energy/on-farm-efficiency.shtml

This tool provides estimated savings from energy conservation options that can be used with your current dryer and compares that data to typical energy usage and costs of other types of dryers:

- http://www.ruralenergy.wisc.edu/conservation/grain_drying/default_graindrying.aspx

[93] Grain Dryers., Alliant Energy.
[94] Farmstead Energy Audit. NDSU Extension Service. Carl Pederson, et. al.
[95] Grain Drying, Scott Sanford. Retrieved at: http://www.uwex.edu/energy/d_BD.html.
[96] Grain Dryers., Alliant Energy.

Utility Rebates!

Dairy

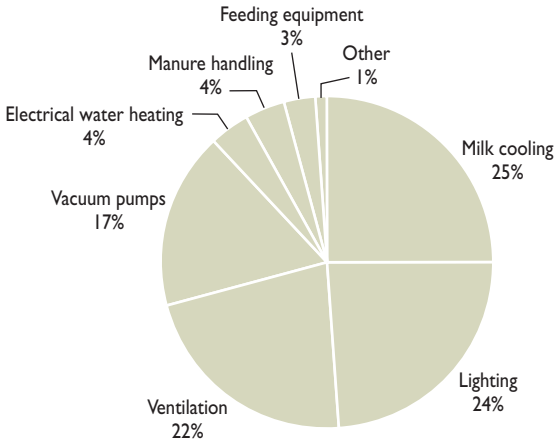
Average utility rebates for Energy Efficient Dairy Production Technologies:

- Dairy Cooling Plates: Varies; up to $500 - $1400 based on herd size
- Milk Precoolers: ~$3.00 per cow
- Variable Speed Drives (noted in HVAC, above) often used on vacuum pumps

Chapter 2: Dairy

ENERGY USE ON A DAIRY FARM

Today's average dairy farm consumes a lot of energy, more so than just a generation ago. Because of the large number of technologies involved in running a successful dairy operation, dairy farms have become one of the most energy intensive farm industries. However, dairy farmers interested in making energy efficiency improvement are in luck, as the research materials and advice on improving energy efficiency in dairy operations exceeds all other farm applications. Today, U.S. dairy farms use between 800 and 1,200 kilowatt-hours (kWh) of electricity per cow, annually.[97] Milk production equipment makes up about 50% of a farm's energy consumption, and lighting, ventilation, and other incidentals take up the rest.[98]



© E SOURCE; data from New York State Research and Development Authority Dairy Farm Energy Audit Summary

Fortunately, there are numerous energy saving technologies, devices, and techniques that any dairy farmer can implement on his or her farm, some of which require no monetary investment whatsoever. With a few key installations, however, a farmer can start saving thousands of dollars every year on energy costs.

Preventative Maintenance/Low Cost Improvements for Dairy Operations

You can start saving money on your dairy farm today without installing new technologies. The following energy reduction techniques can be implemented on your farm immediately at little to no cost.

- Turn off fans when the temperatures drop below 70° F, when dairy cattle are no longer in danger of overheating.[99]
- Decrease pressure on compressors to minimum amount needed; doing so will increase the life of the machine and save 10% on energy costs per 20 pounds reduced.

[97] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[98] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy. Similar figures can be found at: http://datcp.state.wi.us/fs/environment/dfeh/farm_energy_audits.jsp.
[99] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.

- Conserve water to save on heating costs. Reduce water heater temperatures to minimum temperature needed; a decrease of 10° can decrease energy costs 3-5%.
- Clean heat exchanger and condensers coils, saving at least 3-5% of milk cooling costs. Cleaning should be done on a quarterly basis at least.
- Only use hot water when hot water is necessary. Heating water to more than 165°F is unnecessary for the wash cycle, and wastes energy. A warm pre-rinse (100-110°F, followed by a hot wash and cold acid rinse can be just as, if not more, effective than a continuous hot wash cycle.[100]
- Ensure your current vacuum pump is not oversized. If your current vacuum pump has larger capacity than needed, you're likely using more unnecessary energy to run it. If so, rather than replacing the entire system, you should be able to change belts and pulleys to slow the pump down. Finally, check for air leaks on vacuum systems; a faulty vacuum system can cost a farmer in energy loss, slower milking times and poor udder health.[101]

Energy Efficient Dairy Technology Upgrades

Although conserving energy by turning off lights and maintaining equipment can produce worthwhile benefits and energy savings on your farm, more significant savings can be found by installing energy saving equipment. This section highlights the various ways dairy operators save energy and money on all areas of their operation.

Water Heating

As all dairy farmers know, heating water is essential for work on dairy operations. Cleaning milking equipment requires hot water at specific temperatures and amounts. Failure to adequately clean equipment can lead to contamination, subsequent reduction in milk quality, and a potential loss of revenues.[103] With so much at stake, farmers may be cautious in installing energy saving technologies to their water heating appliances. However, the technologies outlined below save energy and money without sacrificing performance.

High-Efficiency Water Heaters

Water heaters have a long life, and the initial cost of a high-efficiency water heater can be repaid many times during the lifetime of the heater.[104] Electric water heaters have the highest efficiency rating in terms of converting energy to heat, as seen in the table below. However, a factor just as important as efficiency is the water heater's insulation level. Standby losses from poor insulation on water heaters can range up to 60% on some water heaters and will result in significant energy waste if not addressed.[105]

Long Day Lighting

As more farmers turn to long day lighting to increase their dairy cows' productivity, switching to energy efficient lighting is becoming increasingly important.[102] To help determine whether long day lighting can be done economically and efficiently on your farm, visit:

- http://www.uwex.edu/energy/pubs/DairyCenterDaylighting.xls

[100] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[101] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[102] Conservation Practices That Save., NRCS (2006).
[103] Washing and Water Heating. Retrieved at: http://www.sce.com/NR/rdonlyres/A1B3766E-5ADB-4B0B-B1F9-DD7F624DEAB4/0/Dairy_Farm_Washing.pdf.
[104] Washing and Water Heating.
[105] Dairy Water Heating, Scott Sanford. Retrieved At: http://www.uwex.edu/energy/dairy_WH.html.

- When purchasing a new water heater, look for a heater with a high Energy Factor rating.[106] Below is a table laying out general efficiency ratings for standard and high efficiency water heaters:[107]

Water Heater Type	Standard Water Heater Efficiency	High Efficiency Water Heaters
Electric	0.7 to 0.85	0.91 or more
Gas (LP or Natural)	0.4 to 0.5	0.61 or more
Oil	0.5 to 0.6	0.61 or more
Heat Pump	N/A	1.5 to 2.0

- Water heaters should have insulation at least 2.5-3 inches with an R-value of 16 or more. Insulation helps a water heater retain heat; improving standby losses, mentioned above. The covering of the heater should be a non-corrosive material like stainless steel or plastic.[108]

Heat Recovery Systems

Farmers spend approximately $70 a month to heat water used to clean milking equipment. Heat recovery systems can erase 60-80% of this cost.[109] Heat recovery systems recover heat lost from milk-cooling compressor units. Recovered heat can be used to help preheat water used for washing milking equipment. Heat from these systems can preheat water more than half of the way toward desired temperatures. Thus, energy use from a water heater may only be required to heat water from 120 to 160 degrees, rather than from 60 to 165 degrees.[110]

Refrigeration/Milk Cooling

A quarter of a dairy farm's energy use is tied up in refrigeration. Thus, any efficiency improvements made in this area of a dairy operation can save producers significant money on their energy budget. Here are some solutions to increasing energy efficiency, and decreasing energy costs, for refrigeration use.[111]

Scroll Compressors

Scroll compressors are a new technology starting to be used more often in dairy refrigeration. Scroll compressors, as opposed to typical reciprocating compressors, have fewer moving parts and no intake or discharge valves.[112] As a result, scroll compressors are quieter, produce less vibration, last longer, and are more reliable than traditional reciprocating compressors.[113]

- Installing a scroll compressor can reduce energy costs associated with the compressor by 15-25%.[114]

[106] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[107] Heating Water on Dairy Farms., Scott Sanford; UW-Extension. (2003). Retrieved at: http://www.mainerural.org/energy/fieldguide/dairyheatingwater.pdf.
[108] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[109] Minnesota Farm Incentives. Alliant Energy.
[110] Minnesota Farm Incentives. Alliant Energy.
[111] Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[112] Dairy Refrigeration, DLtech, Inc. and NATC. (2004).
[113] Dairy Farms: Energy Saving Ideas. Efficiency Maine.
[114] Energy Management for Dairy Farms., Richard Peterson; NATC-NY. Retrieved at: http://www.mainerural.org/energy/fieldguide/dairyfarms.pdf; Dairy Farms: Energy Saving Ideas. Efficiency Maine.; http://www.mainerural.org/energy/fieldguide/dairyrefrigeration.pdf

Plate Coolers/Pre-Coolers

Plate Coolers, also known as precoolers or plate heat exchangers, transfer heat from the milk to water. Milk leaves the cow at a temperature around 98-102 degrees, and needs to be rapidly cooled to less than 40 degrees.[115] A precooler reduces the temperature of the milk by passing it through the cooler in the opposite direction of water, separated by metal plates. The heat from the milk transfers to the water, cooling the milk to 55-70 degrees while warming the water.[116] The cooled milk is transferred to the holding tank, where it is cooled further by the compressor.

- Precooling reduces cooling costs by 15-30%, and cooling requirements by 50%.[117] Thus, precoolers can pay for themselves in as little as two years.
- Precoolers also reduce the number of hours your refrigeration compressor works, by as much as half.
- Like heat recovery systems, warmed water from precooling can be used for a number of projects such as watering cows, washing down the animals, and washing the milking parlor, which limits the use of your water heater.

As the previous discussion indicates, the various heat recovery and refrigeration technology improvements on a dairy operation are all interconnected. The efficient use of one technology will cut down on the use of another. Thus, when considering installing a precooler, scroll compressor or heat recovery system, producers should keep their entire system in mind to determine the usefulness of installing one technology over another. Depending on the needs of the farm, it is not necessarily economical to install all available technologies, and some will work better together than others.[118]

Pump and Motor Systems

As with other areas of the farm, pumps and motors are a big part of dairy operations. On a typical dairy, pump and motor systems can use up to 20-25% of a dairy farm's energy.[119]

- Use variable speed drives on your milking vacuum pumps.[120] Adding a VSD to your pump can reduce pump energy expenditure by 50% or more.[121] The initial cost of installing VSDs can be made up within one to three years.[122]
- Additionally, consider automatic take-off milker units. Automatic milker take-offs remove milking claws when milk flow reduces down to a level preset by the farmer. Automatic take-offs prevent over milking and reduce vacuum system runtime.

Dairy Energy Efficiency Tools and Calculators

The Dairy Energy Self Assessment Tool takes information about your farm and gives advice on different equipment that will help you achieve potential energy savings:

- http://www.ruralenergy.wisc.edu/conservation/dairy/default_dairy.aspx

To calculate potential savings from installing automatic milker take-offs visit:

- http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014901

To calculate potential savings from installing milk precoolers visit:

- http://www.alliantenergy.com/UtilityServices/ForYourFarm/EnergyConservation/014900

[115] Plate Coolers., CET Online. Retrieved at: http://cetonline.org/FarmBusiness/plate_coolers.php.
[116] Dairy Farms: Energy Saving Ideas. Efficiency Maine.
[117] Dairy Farm Energy Management Handbook: Equipment Operation and Maintenance. Wisconsin Department of Ag, Trade and Consumer Protection.
[118] For more information see: http://www.mainerural.org/energy/fieldguide/wellprecoolers.pdf
[119] Dairy Farm Energy Management Guide.
[120] Conservation Practices That Save., NRCS (2006).; Energy Efficiency and Farm Equipment., Institute for Energy and the Environment.; Managing Energy Costs in Dairy Farm Facilities., Xcel Energy.
[121] The Farmer's Handbook for Energy Self-Reliance., Institute for Energy and the Environment. (2007).; Dairy Farms: Energy Saving Ideas. Efficiency Maine.
[122] Minnesota Farm Incentives. Alliant Energy.; Dairy Farm Energy Management Guide.; Vacuum Pump Variable Speed Drives. Adam Holmes, EnSave, Inc.

Chapter 3: Beef Operations

Farmers involved in the beef industry should find a number of the tips concerning building improvement in the above chapters useful to their operations. While beef operations may not be the most energy intensive, this chapter adds a few more tips that may help beef producers realize additional savings.

Solar Powered Fencing

As most producers likely know, solar powered electric fencing is available as an alternative to traditional electrical fencing needs. It is just as efficient as traditional electric fencing methods, and doesn't require a connection to your electrical system.

- Solar chargers can cover areas ranging from 3-35 miles of electric fence.
- After the initial cost of equipment and maintenance costs, there are no additional electricity costs to operate an electric fence.[123]

Cattle Waterers

Economize your cattle waterers. Cattle require large amounts of water daily. By delivering water to cattle efficiently, you can save money on both your energy and water bill. The biggest problems and energy use concerning cattle waters comes in the winter, when producers constantly struggle to keep water sources open from freezing. While not necessarily the largest farm cost, improving water system performance can save you money and seasonal headaches.

- Typical livestock waterers can consume up to 36 kWh of electricity per day, during the coldest parts of the year. Energy efficient waters can cut energy costs anywhere from 20-80% based on level of insulation, heat element efficiency, and cattle use.[124]
- Keep the water thermostat at a few degrees above freezing. This should prove sufficient for keeping the small water space unfrozen. Make sure that your current water pump is not leaking or overflowing consistently. This wastes both energy and water.
- Consider changing from a heated water fountain to an unheated super-insulated water fountain. These have been proven to be an efficient way to provide water to livestock without requiring any supplemental energy.[125]

Utility Rebates!

Beef

Average Utility Rebates for Energy Efficient Beef Operation Technologies:

- Energy Efficient Cattle Waterers:
  Cost Share or $40 per unit installed

Beef Energy Efficiency Tools and Calculators

This tool will help identify areas of your beef operation that could merit some energy efficiency improvements. After inputting basic information from your farm, this tool will suggest some areas of potential improvement:

- http://www.ruralenergy.wisc.edu/conservation/livestock/default_livestock.aspx

In conjunction with the previously mentioned tool, this evaluation tool focuses specifically on ways to improve livestock waterers:

- http://www.ruralenergy.wisc.edu/conservation/waterfountain/default_waterfountain.aspx

[123] Solar Electric Fence Guide. http://www.solarelectricfence.org/
[124] Automatic Livestock Waterers. The Dairy Site. (2008). Retrieved at: http://www.thedairysite.com/articles/1930/automatic-livestock-waterers.
[125] Energy Conservation Tools, Livestock. USDA National Resources Conservation Service. http://www.ruralenergy.wisc.edu/conservation/default.aspx

Chapter 4: Pork Operations

This short section gives a few industry specific tips for pork producers. As producers might imagine, most efficiency efforts in pork production should be focused on conserving heat costs and livability. Be sure to check the other chapters for efficiency tips that cover more general farm operations, such as lighting and motor improvements..

Insulation/Ventilation

- In a typical swine production facility, 80-95% of heat loss is associated with ventilation. Therefore, proper ventilation management is very important when considering energy efficiency.[126] Specific recommendations for Minnesota swine buildings state they be insulated with an R-value of 33 in the ceiling, 20 in walls, and have perimeter insulation.[127]
  - Improving from R 30 to R 40 insulation in ceilings could save $63 per year.[128]
  - Improving from R 10 to R 30 insulation in ceilings could save $524 per year.[129]
  - Add insulation to concrete sidewalls. This can raise the inside temperature of a barn without increasing the size of your heating bill.
- Consider using hovers in farrowing rooms. This will allow a small area to be heated to a warmer temperature, thus saving the use of both electricity and natural gas to heat the entire room at a higher temperature.[130]

Pork Specific Lighting/Heating

Using more energy efficient 175W lamps vs. conventional 250W lamps will save a great deal of energy.[131] Benefits of these types of lamps include:

- Annual energy savings of $36 per unit or $5,500 per 1,000 sows.
- Improved livability, saving 284 extra pigs per 1,000 sows per year.
- A 50% reduced lamp failure rate.

Utility Rebates!

Pork

Average Utility Rebates for Energy Efficient Pork Production Technologies:

- Up to 50% cost share for implementing microcove farrowing practices.

Pork Energy Efficiency Tools and Calculators

This evaluation tool helps estimate energy budgets for pork housing operations, and can help producers begin to identify where to make energy efficiency improvements:

- http://ahat.sc.egov.usda.gov/

[126] Energy Efficiencies for Cutting Back Your Power Costs., Jay Harmon, Iowa State University Extension.
[127] Energy Efficiencies for Cutting Back Your Power Costs., Jay Harmon, Iowa State University Extension.
[128] Energy Efficiencies for Cutting Back Your Power Costs., Jay Harmon, Iowa State University Extension.
[129] Energy Efficiencies for Cutting Back Your Power Costs., Jay Harmon, Iowa State University Extension.
[130] Save Energy in the Farrowing Room With Hovers. Larry Jacobson and Lee Johnston. (2010). Retrieved at: http://www.extension.umn.edu/distribution/livestocksystems/DI6513.html.
[131] Energy Efficiencies for Cutting Back Your Power Costs., Jay Harmon, Iowa State University Extension.

Chapter 5: Poultry Operations

There is currently a lack of energy efficient resources relating to the poultry industry. While some of the more general energy saving methods, such as lighting, heating and ventilation are covered by other chapters, this chapter will give tips specific to addressing energy saving methods unique to the poultry industry.

Poultry Energy Efficiency Tools and Calculators

This USDA sponsored tool will help you determine potential inefficiencies in your poultry operation and suggest ways you could improve your energy budget:

- http://ahat.sc.egov.usda.gov/

Ventilation

There are many different types of ventilation that can be used in poultry barns. The three most common are an exhaust or negative pressure system, a positive pressure system, or a naturally ventilated barn.[132] In all of these systems it is important to make sure that air is moving throughout the poultry house and that it is at a constant temperature throughout the poultry house.

- Aim for a static pressure of around 20 in all poultry houses. This will mix air entering the building with air already in the building and keep temperatures stable.[133]

Air Heating and Cooling

Heating costs make up a large portion of a poultry farmer's energy bill. By making sure that all the walls have been properly insulated both inside and outside a poultry house, the cost of a typical poultry operation can save 10-20% on heating costs.[134] Not only will your energy bill be lower, birds are more comfortable at a constant temperature.

- Employing heat exchangers in poultry operations can save you 40% of the energy required for boiler brooding.[135]

[132] Poultry Housing, W. Winchell, Canada Plan Service. Retrieved at: http://www.cps.gov.on.ca/english/plans/E5000/5000/5000L.pdf
[133] SUNUPTV Retrieved at: http://www.youtube.com/watch?v=Or1Y-uya-co&feature=related

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