ENERGY-RELATED AGRICULTURAL BEST PRACTICES

Guidebook

For Dairy Farms

New York State | NYSERDA

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Dairy Farm Energy Best Practices Guidebook

Energy-efficient technologies, processes, and practices create opportunities to optimize farm energy use and lower operating costs. This best practices guidebook provides energy-related information to provide farms with a better understanding of farm energy use, energy-efficient technologies, alternate modes of operation, and practices that optimize energy use to assist in making sound investment decisions and incorporate energy efficiency into daily practices.

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Energy Solutions for the Modern Farm

EnSave is an agricultural energy services company committed to helping its clients achieve their resource conservation goals. Over its 30-year history, EnSave has designed and implemented energy and greenhouse gas reduction programs for energy utility companies, federal agencies, state governments, and agricultural cooperatives.

Table of Contents

Introduction

Dairy farms have among the highest energy use of all types of agriculture. Fortunately, there are many technologies farmers can implement on the farm to significantly reduce their energy usage and utility costs. Some of these technologies can also improve cow comfort and farm production processes.

Energy Use Basics

The energy pyramid provides a useful way to consider energy management on your farm. Starting at the base, the pyramid begins with the easiest and most cost-effective options.

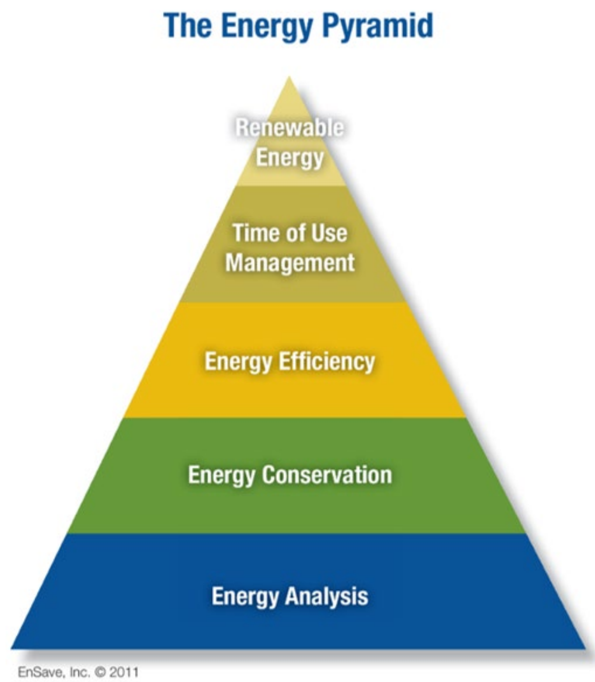
A Cost-Effective Approach to Reducing Energy Costs

Dairy producers who are seeking to cost-effectively minimize their energy expenses should follow the energy pyramid when identifying opportunities for energy cost savings.

An initial energy analysis or audit is used to evaluate farm energy use and cost-saving opportunities before making any investments. The goal of this analysis is to identify energy conservation and energy efficiency projects that will be most effective in reducing the overall energy needed on the farm.

Once energy use has been minimized, time-of-use management can sometimes be utilized to reduce the cost of power from the electric utility. This can be determined with a review of the utility rate categories along with farm equipment operating times and energy use. Finally, once energy usage and cost have been minimized, a renewable energy assessment can be performed to determine the feasibility, size, and cost-effectiveness of renewable energy systems.

There are many well-established practices that reduce overall energy use on dairy farms. This guide focuses on the fundamental three bottom tiers of the energy pyramid, with steps and information for the top two once completed.

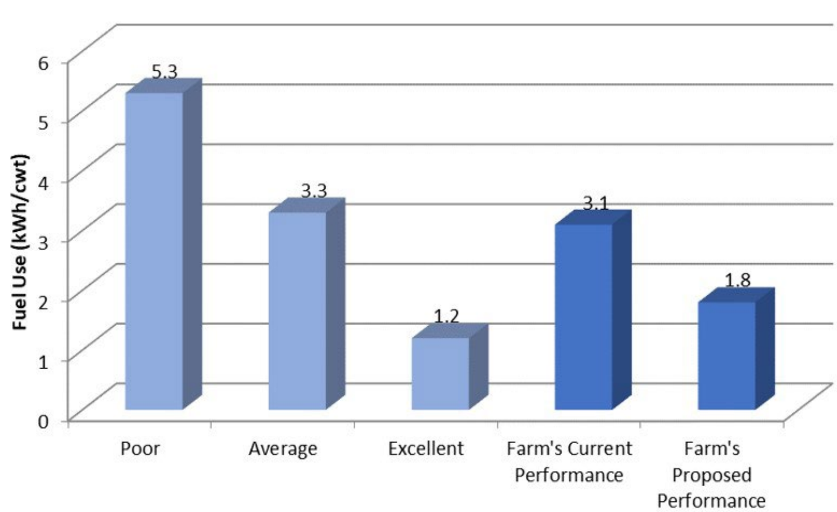


Energy Use Analysis and Audits

Every farm has varying opportunities for energy savings. An energy audit is a way to understand your farm's unique energy profile and cost saving possibilities. This can be a first step toward reducing energy usage. The Energy Conservation and Efficiency Projects section provides a list of best practices for reducing energy usage.

Energy use on a farm can be thought of in terms of how much energy is used per hundredweight of milk produced. Farms of similar type and size in comparable climates should have similar energy use. Collectively they can be evaluated to determine typical energy use and cost savings once best practices are implemented. Figure 1 shows total electrical energy used (kWh) per hundredweight (cwt) of farm milk. In this example, the farm's current energy performance is compared against proposed performance after energy efficiency and conservation measures are installed, and is also benchmarked against peer farms with poor, average, and excellent performance. The goal of energy analysis is to determine how a farm can go from average energy use to as efficient as possible.

Figure 1. Example Farm Energy Use Comparison.



Energy Conservation

Energy conservation is a change of processes or equipment that results in less energy use. Most energy conservation measures are simple actions you can take with your existing setup to reduce energy usage. An example of conservation actions for farm lighting and heating systems is to turn off the lights when you leave the room, turn down the thermostat, or using timers and motion sensors. Each farm system has different opportunities for energy conservation. Generally, conservation activities are low- to no-cost, but may not save as much energy as energy-efficient equipment.

Energy Conservation

Process Improvements: Sometimes energy can be conserved by changing the order or method for how work is done. For example, utilizing natural sunlight and ventilation will save on energy cost associated with lighting and cooling. You can also conserve energy by utilizing waste heat from one process to add heat to another process.

Reducing Equipment Run-Hours: Anything that is plugged in or turned on uses energy. Turning that equipment off and only running it when needed reduces equipment running hours and saves energy.

Use of Switches, Timers, and Sensor-Based Controls: Timers and sensors are great for energy conservation and are small investments that can save money without having to remember to do things differently. Anything that is using power when idle is an opportunity for automatic shutoffs. Anything that can be controlled with light, dark, motion, temperature, fluid levels, and other environmental conditions may be an opportunity for automatic controls. An area of the farm that is only used during certain times of day or for brief periods is an opportunity for motion sensors, dimmers, and timers, especially for lighting. Consider using these in entrances, hallways, and storage areas. Heating and cooling systems present opportunities for temperature and schedule-based controls. Remote control options are also available for some equipment, such as lights and thermostats, and can be turned on, off, or adjusted from a smartphone or computer.

Maintenance: Performing regular service and maintenance of structures and equipment is the best case for efficient operation and long lifespan. This includes various motors, pumps, and cooling equipment, as well as non-mechanical components, such as insulation, weather sealing, and lighting.

Energy Efficiency

Energy efficiency refers to using less energy by changing equipment or a system design to more efficient ones. Each farm system has different opportunities for energy efficiency. Replacing the lights or furnace with a more efficient model, reconfiguring a system to do the same task with less energy, or changing to a more efficient fuel source, are all examples of reducing energy use without reducing the quantity or quality of farm products. This guide contains many recommendations for energy efficiency upgrades. Generally, energy efficiency measures have a cost, but the cost is worthwhile due to higher energy savings creating a quick return on investment and often provide other benefits such as improved working conditions.

Energy Efficiency

Equipment Upgrades: Technology is changing and improving continuously, and there are many options to reduce energy costs by installing these new technologies. Often this is done when equipment reaches the end of its life, but depending on the age and type of equipment, it may be worthwhile to make the investment to change the equipment before it fails because the energy cost savings are high. The time it takes for energy savings to payback the cost of the equipment is known as the payback period. After the payback period has been reached, all the energy savings go to the farm's bottom line.

System Design Improvements: Sometimes changing the design of a system can result in significant energy savings. For example, adding a refrigeration heat recovery unit to a cooling process allows extraction of the removed heat that can be used for other purposes. On a dairy farm, heat recovery can be done by utilizing the milk cooling process to preheat hot water for use in sanitation or other processes.

Fuel Switching: Changing to a fuel source that operates equipment more efficiently, or is a more cost-effective fuel, can offer significant savings. Actual savings vary by regional energy source availability and by the cost of connecting to the new fuel source, which should be considered when upgrading equipment. Examples of fuel switching include switching from oil to natural gas, or propane, or from any fossil fuel to electricity.

Energy Use on Dairy Farms

There are a variety of energy uses on the farm that can benefit from conservation and efficiency projects. Some uses have more opportunity for energy savings than others but looking at the whole farm will aid in planning for the future. Understanding whole farm energy use is a critical first step to optimizing production efficiency and minimizing operating costs.

Farm Energy Conservation and Efficiency Opportunities

Facility Lighting

Facility Heating, Cooling, and Ventilation

Milk Harvesting

Milk Cooling and Storage

Milk Processing

Crop Irrigation and Production

Tractors and Equipment

Feed & Water Handling and Storage

Manure Separation and Handling

On-Site Power Generation

Typical Dairy Farm Energy Use and Opportunities

In New York, dairy farms have several key opportunities for energy improvements. Figure 2 describes typical energy usage by farm equipment or process. Each of these represents significant potential energy savings.

Table 1 provides a summary of energy best practices and paybacks for New York dairy farms in each energy use category. The typical savings percentage describes how much a typical farm saves on annual energy costs by completing the recommended improvement. This percentage is the reduction in energy cost from equipment typically used for the same purpose, not from total farm energy cost. Additionally, some changes interact so the savings do not always add together. For example, if a variable frequency drive (VFD) is added to a motor, and the motor is upgraded to a high-efficiency model, the energy use of the new system is based on how the two parts work together, not by adding the individual reduction estimates of each.

The value of completing recommendations is estimated by the payback period. The payback period is how many years of energy savings it takes to cancel out the initial investment required to make the improvement. Once the payback period is achieved, the annual energy cost savings go directly to the business' bottom line.

Each of these potential improvements is described in detail in this guide, including system design and equipment recommendations. For all farm energy use categories, low-cost and maintenance best practices are also provided. References to equipment selection guidelines and independent performance efficiency rating agencies are included; however, each usage will have to be evaluated individually to determine the exact make and model appropriate. Working with an equipment dealer or manufacturer will be required for final selection and installation information, but the efficiency rating agency resources can be used to compare the make and model of various equipment to determine which will achieve more energy savings. The back of this guide includes additional resources for process and technical support, funding opportunities, and more.

Figure 2. New York Dairy Farm Energy Use. Source NYSERDA Dairy Farm Energy Audit Summary Report, 2003.

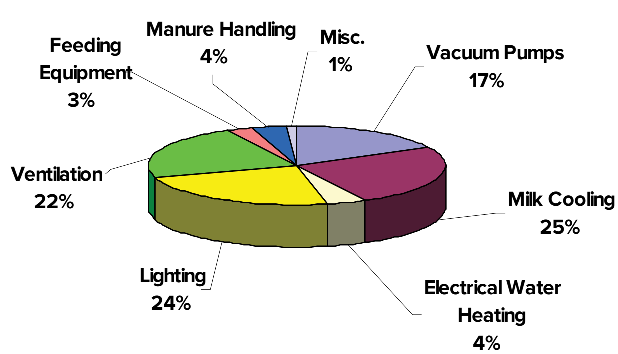


Table 1. Summary of Recommended Energy Conservation and Efficiency Best Practices.

Description	Potential Improvements	Typical Savings (% energy cost reduction)*	Typical Payback (years)*
Farm Lighting	Upgrade to high-efficiency LED lighting technology	60%–80%	2.5
	Install lighting controls such as timers and sensors	30%–50%	2
Milking Equipment	Add variable frequency drive (VFD) to milk vacuum pump	50%–60%	3.5
Milk Cooling and Storage Equipment	Add milk pre-cooler	20%–60%	3
	Add variable frequency drive (VFD) to milk transfer pump	5%–15%	4.5
	Upgrade bulk tank refrigeration compressor/condenser to a high efficiency technology such as a scroll compressor	15%–20%	6
	Add heat recovery unit to bulk tank refrigeration system	20%–60%	3
Water Heaters	Install pipe insulation	3%–4%	12.5
	Upgrade to high efficiency water heaters	10%–50%	5
	Utilize heat recovery from milk cooling system	20%–60%	3
Air Circulation and Exhaust Fans	Upgrade circulation fans to high efficiency fans	20%–35%	8
	Replace circulation fans with high-volume low-speed fans (HVLS) where appropriate	50%–65%	8
	Upgrade exhaust fans to high-efficiency fans	20%–30%	8
	Install automatic fan controls, program schedules	5%–12%	3
Various Use Motors	Upgrade AC induction motors to NEMA Premium® rated models	2%–5%	9
	Upgrade small motors to ECM models	65%–75%	3
	Install motor controls for uses with varying motor loads	50%–80%	3
	Install timer control on engine block heaters	65%–90%	1
	Convert internal combustion engines to electric motors	20%–50%	4.5
Stock Waterers	Install energy free or low energy waterers	40%–100%	3.5
Building Heating	Install building insulation and sealing around openings	3%–15%	3.5
	Install automatic temperature controls, program schedules	5%–12%	4.5
	Install strip curtains or air curtains	10%–40%	3
	Upgrade space heaters to high efficiency models	5%–30%	7.5
Washing Machines	Upgrade to ozone washer	40%	½ to 1
	Upgrade to high efficiency commercial washer	25%	6.5

**See Typical Savings and Payback explanations in section narrative.*

New York Dairy Case Study

The following is a real-world example of a mid-sized New York dairy farm that will save an estimated $8,000 per year in energy costs by investing in energy improvements on their farm. While it will take an initial investment to realize these savings, in less than seven years this investment will have paid back through the reduced energy costs. By year 10, they will realize an estimated net gain of about $43,500, while still saving approximately $8,000 each year thereafter. At the time of the audit, energy efficiency rebates were available from the utility provider (National Grid), and the Natural Resources Conservation Services (NRCS) Environmental Quality Incentives Program, which further reduced investment cost and payback duration.

The 500-acre dairy farm milks 175 cows twice a day producing around 9,600 pounds of milk daily. They have three barns, a shop, and a residence on the property. Most of the milking equipment was installed in 1994. When the farm heard of the possibility of saving energy costs through the NYSERDA Agriculture Energy Audit Program, they wanted to learn more about the process and potential benefits. They were also interested in knowing the best options for upgrading some of their old equipment and improving productivity. After speaking with a program representative, they decided to have an agriculture energy audit performed to identify key opportunities for energy savings, as well as optimal system configurations and equipment selections.

Dairy Farm.

The audit report identified multiple energy and cost saving measures with equipment investment recommendations and operational changes that will reduce operating costs and update their systems. Table 2 provides a summary of audit recommendations, estimated investment costs, and annual savings. As with many dairy farms, installing high-efficiency, long-life light-emitting diode (LED) lighting, and changing the setup of the milk cooling system would provide significant savings with relatively short payback periods. Other technologies, such as circulation fans, were evaluated but found to be energy efficient, so no recommendations were made.

Technologies and recommendations are discussed in detail in the following sections. This case study illustrates some of the potential energy saving opportunities. Each farm is unique and must be analyzed on a case-by-case basis, which is exactly what the energy audit delivers.

Table 2. Energy-Saving Recommendations for Example New York Dairy Farm.

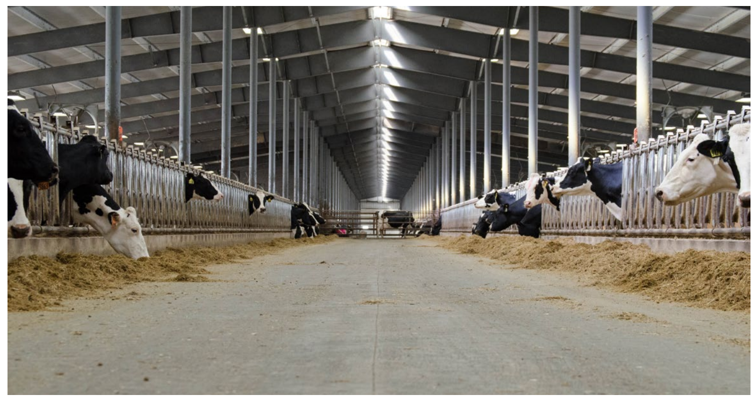
	Improvement Recommendation	Estimated Annual Electric Savings (kWh)	Estimated Annual Cost Savings ($)	Estimated Cost to Install ($)	Estimated Payback (Years)
1	Replace incandescent, fluorescent, and HID lighting across the whole farm with LED lighting	10,300	$1,440	$4,900	3.4
2	Replace existing reciprocating type compressor on milk cooling tanks with a scroll type compressor	7,500	$1,050	$13,900	13.2
3	Add a plate cooler to milk cooling system	11,300	$1,580	$8,450	5.3
4	Install a variable speed drive controller on the milking vacuum pump	6,700	$950	$10,000	10.5
5	Install a variable speed drive controller milk transfer pump	3,200	$450	$4,950	11.0
6	Install low-energy stock waterer	1,400	$195	$600	3.1
	Improvement Recommendation	**Estimated Annual Propane Savings (Gallons)**	**Estimated Annual Cost Savings ($)**	**Estimated Cost to Install ($)**	**Estimated Payback (Years)**
7	Install insulation on hot water pipes across the whole farm	89	$240	$160	0.7
8	Replace existing water heaters with efficiency water heater	248	$675	$3,750	5.6
9	Install pre-heating unit to recover waste heat from milk cooling system to pre-heat domestic hot water	602	$1,630	$5,950	3.7
TOTALS: yearly cost savings, total installed cost, and combined improvement payback period		–	$8,210	$52,660	6.4

Energy Conservation and Efficiency Projects

Farm Lighting

Upgrading to more energy-efficient lighting and adjusting the lighting fixture layout are among the most common and cost-effective ways to save energy on dairy farms. This can also be an opportunity to upgrade lighting to improve working conditions and potentially increase cow productivity. While it may seem practical to replace light bulbs and fixtures as they burn out over time, in many cases it is more cost effective to make a proactive investment and upgrade entire lighting systems as early as possible.

LED lighting technology is now the most practical technology choice for energy efficiency and the best quality lighting. Many types of LED fixtures and bulbs are available that have been designed to meet most lighting needs and operating environments. LED bulbs last longer than any other technology and often come with manufacturer warranties, making them the best long-term value. Organizations such as EnergyStar® and DesignLights Consortium® (DLC) provide independent testing and rating of LED products and provide guides for selecting the best and most efficient ones.



Light Level Recommendations

Lighting level recommendations have been developed by the American Society of Biological and Agricultural Engineers for common areas on dairy farms to ensure lighting will be adequate for work tasks, animal comfort, and optimal animal productivity. These recommendations, commonly known as lighting adequacy, or illuminance recommendations, are given in units of foot-candles (English units) or lux (metric units), which describe the amount of light in the working area as measured by a light meter. Table 3 presents the recommended light level for various work area locations around the farm.

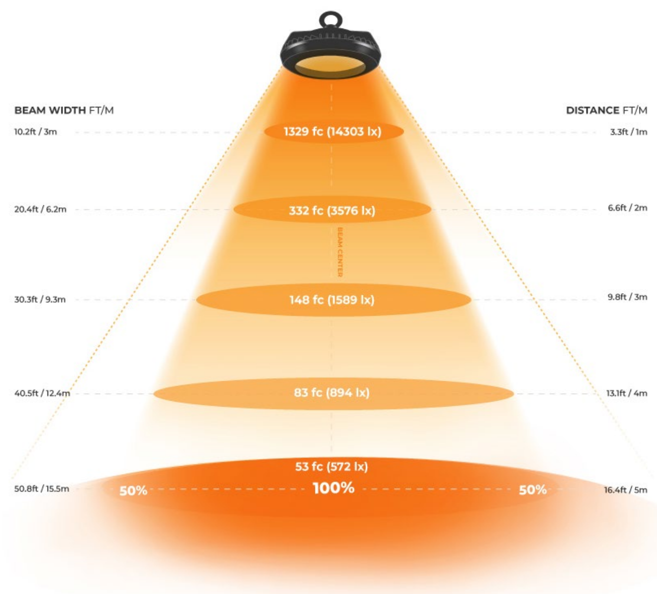
Table 3. Light Level (Illuminance) Recommendations for Dairy Uses. Source: Sanford, Energy-Efficient Agricultural Lighting, 2003.

Location	Recommended light levels in foot-candles	Recommended light levels in lux	Location	Recommended light levels in foot-candles	Recommended light levels in lux
Exterior active areas	3 to 5	32 to 54	Milking parlor	20	200
Exterior security	½ to 1	5 to 10	Operator's pit (at udder)	50	500
Farm shop/repair area	50	538	Milk room	20	200
Free stall	20	200	Washing area	100	1000
Tie stall (feed ally)	20	200	Bulk tank interior	100	1000
Tie stall (center ally)	20 to 50	200 to 500	Loading and storage areas	20	200
General animal care area	20	200	Office area at desktop	50	500
General livestock housing	10	100	Restroom	20	200
Treatment or surgery area	100	1000	Utility room	20	200
Holding area	10 to 20	100 to 120	Machine storage	10	100

When selecting light bulbs, installing, or upgrading fixtures, and maintaining lighting over time, several considerations are made to ensure the foot-candle specification are achieved in each work area. If an energy audit has been performed on the farm, recommendations will be made to achieve these light levels. Some dairy farm lighting vendors will provide a lighting level analysis as part of their initial consultation. You can also do your own evaluation by using a light meter to measure foot-candle (or lux) light levels in the various work areas and make changes as needed. Basic light meters are relatively inexpensive.

Lighting Selection and Installation

When analyzing lighting systems, the most important characteristics are light quality and energy efficiency. There are several ways to change the lighting in the work areas to both save energy and meet the light level adequacy recommendations. Often that means changing the lighting technology or bulb rating, but light fixture layout and bulb maintenance can also provide simple, cost-saving opportunities. The quality of the lighting installation is also influenced by the color of the light, light uniformity, glare, and reflections off of surfaces.



Example Lighting Illuminance Pattern for LED Fixture.
Credit: SuperBrightLEDs.

Use a Light Meter for Dairy Lighting Adequacy.

Older dairy facilities may require additional fixtures and lighting to meet the minimum light level recommendations. Using energy-efficient LED technology for these upgrades will minimize the impact of additional fixture energy costs and, if done as part of a full facility lighting upgrade, may still be an overall cost savings. Meeting the minimum light recommendations has been shown to increase cow productivity and is more comfortable for workers, which also adds value to the farm.

Farm Lighting Equipment Upgrades – Key Considerations

Technology Options: The most common and practical energy-efficient lighting options today are light emitting diode (LED) fixtures. They are available in many shapes and sizes and designed to replace older technologies for most applications. LED lighting technology has advanced so quickly over the past decade that older LEDs can often be cost effectively replaced with newer generation LEDs.

Brightness Rating: The bulb or fixture brightness rating is provided by the light bulb manufacturer and is measured in lumens. Lumens are the actual amount of light the bulb produces regardless of the amount of energy (watts) it consumes to do so. The higher the lumens, the brighter the bulb. Because many people are used to older technologies and think of brightness in terms of watts, many LED manufacturers also provide an “incandescent equivalent watt rating.” To conserve energy, use only the brightness required for the task.

Energy Efficiency: Lighting energy use efficiency is rated in lumens per watt. The higher the lumens per watt, the more efficient the bulb. To qualify for rebates, many programs require light bulbs and fixtures to be EnergyStar® or DesignLights Consortium® listed.

Environmental Protection: Consider where the light will be located and if it should be in a sealed, waterproof housing, or protected from dirt and dust. Some lights are available with environmental protection ratings, while others can be installed inside of a protective enclosure. Verify the lighting temperature range is appropriate for the use.

Bulb Shape, Color Temperature, and Light Quality: These factors affect how the light will appear throughout the room. LED lighting comes in a range of options and should be chosen as appropriate and appealing for the intended use.

Life Cycle and Quality Ratings: LED products vary widely between manufacturers. When selecting lighting products, compare the rated lifespan, manufacturer warranties, and quality ratings. Independent test labs such as EnergyStar® or DLC list products that meet high-quality and efficiency standards. These are a good choice and often a requirement to qualify for rebates.

Example High Intensity LED Light with Reflective Fixture.

Multi-Purpose and Facility Lighting Controllers.

Low/No-Cost Options

Natural Lighting: Utilize daylight when possible.

Automatic Controls: Light timers, dimmers, and sensor-based controls, such as motion and sunlight sensors, offer excellent and low-cost way to save energy. They are available for individual lights or as lighting control units for the whole facility. Remote options are also available so lights can be adjusted from a smartphone or computer.

Maintenance and Cleaning: Cleaning off light bulbs, reflectors, and light covers can dramatically improve light levels and reduce the bulb brightness rating required for a work area. Clean off every six months to a year.

Fixture Location: The closer the light is to the work area the brighter it will be, but the less spread it will have. The effect varies with lighting technology but is generally the case for all types. The most energy-efficient lighting configuration balances fixture height and brightness rating to provide the right amount of lighting (light level) to the work area with the lowest total energy (watts) of all lights in that area.

Long-Day Lighting: Long-day lighting is the practice of using supplemental lighting to mimic and extend daylight hours in the barn on a schedule and, in some studies, proven to increase cow productivity. While this practice does not directly save energy, it may increase farm productivity and reduce overall energy used per hundredweight of product produced. Use of efficient lighting technology and simple lighting controls, such as timers, enables effective implementation of this practice.

Table 4. Typical Energy Savings for Farm Lighting Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Change Light Bulbs to LED*	60–80%	$1–$350 each	2.5
Installed Automatic Lighting Controls	30–50%	$50–$10,000+	2

**Bulbs must be DLC listed to get utility rebates.*

Online Lighting Energy, Selection, and Long-Day Lighting Guides

- https://www.designlights.org (DLC listings and selection guide)
- https://www.energystar.gov/products (EnergyStar® listings and selection guide)
- https://www.epa.gov/cfl/recycling-and-disposal-cfls-and-other-bulbs-contain-mercury#other (old bulb recycling information)
- https://www.canr.msu.edu/news/increase_milk_production_and_reduce_energy_consumption_with_long_day_lighti (long day lighting practices for dairy farms)

Milking Equipment

Milking equipment includes the milking units and pumping system used to harvest milk. On average the vacuum pump used for milk harvest consumes 15–25% of a dairy farm's electricity usage. Robotic milking systems are self-contained systems that cannot be improved (the cost savings of these systems is in labor, not energy), but conventional systems offer a significant opportunity for energy savings.

Because these systems are simultaneously connected to many milking units, the number of cows actively being milked varies, and so the vacuum pressure needed from the pump also varies. Adding a VFD to the vacuum pump motor and a pressure sensor to the milk line enables automatic adjustment of the motor speed based on demand rather than running at a constant maximum speed with varying pressure. The result is the pump runs at a much lower speed most of the time and uses substantially less electricity during milking, but when needed (such as during the vacuum line wash cycle) the VFD will ramp the motor up to maximum speed. An added benefit of this setup is that pumping noise levels are dramatically reduced during milking, and pump and motor internal components last longer and require less frequent maintenance.

Replacing the milking pump motor with a high-efficiency model may also provide an opportunity for energy savings and may be required for VFD compatibly. Refer to the Various Use Motors, Fans, and Pumps section of this guide for details on motor upgrades.

Milk Vacuum Pump and VFD.

Milking Equipment Upgrades – Key Considerations

Variable Frequency Drive (VFD): For compatible pumps, a simple and effective opportunity for energy savings is to install a VFD controller on the pump motor.

Pump and Motor Type: A VFD will only work with certain types of pumps and motors so upgrades may also be required to use the controller. Rotary lobe type pumps and some sliding vane pumps may be compatible, while water ring and turbine type pumps need to be replaced. The motor must be a three-phase AC induction type to be controlled by the VFD.

Pump Motor Efficiency: It may be worth replacing the pump motor with an energy-efficient model, such as a NEMA Premium® motor. If the motor must be replaced for VFD compatibility, this is the standard practice. Refer to the Various Use Motors, Fans, and Pumps section of this guide for details.

Low/No-Cost Options

System Maintenance: Regular maintenance of the pump and motor will ensure they are running as efficiently as possible. Cleaning and maintaining pulsators, filters, drains, hoses, and gaskets, and repairing leaks in the milking system makes it easier for the vacuum pump to maintain pressure without using extra energy.

Table 5. Typical Energy Savings for Milking System Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Install Milk Vacuum Pump VFD Controller	50%–60%	$4,500–$10,000	3.5 years
Install High Efficiency Milk Pump Motor	2%–5%	$500–$1,500	9 years

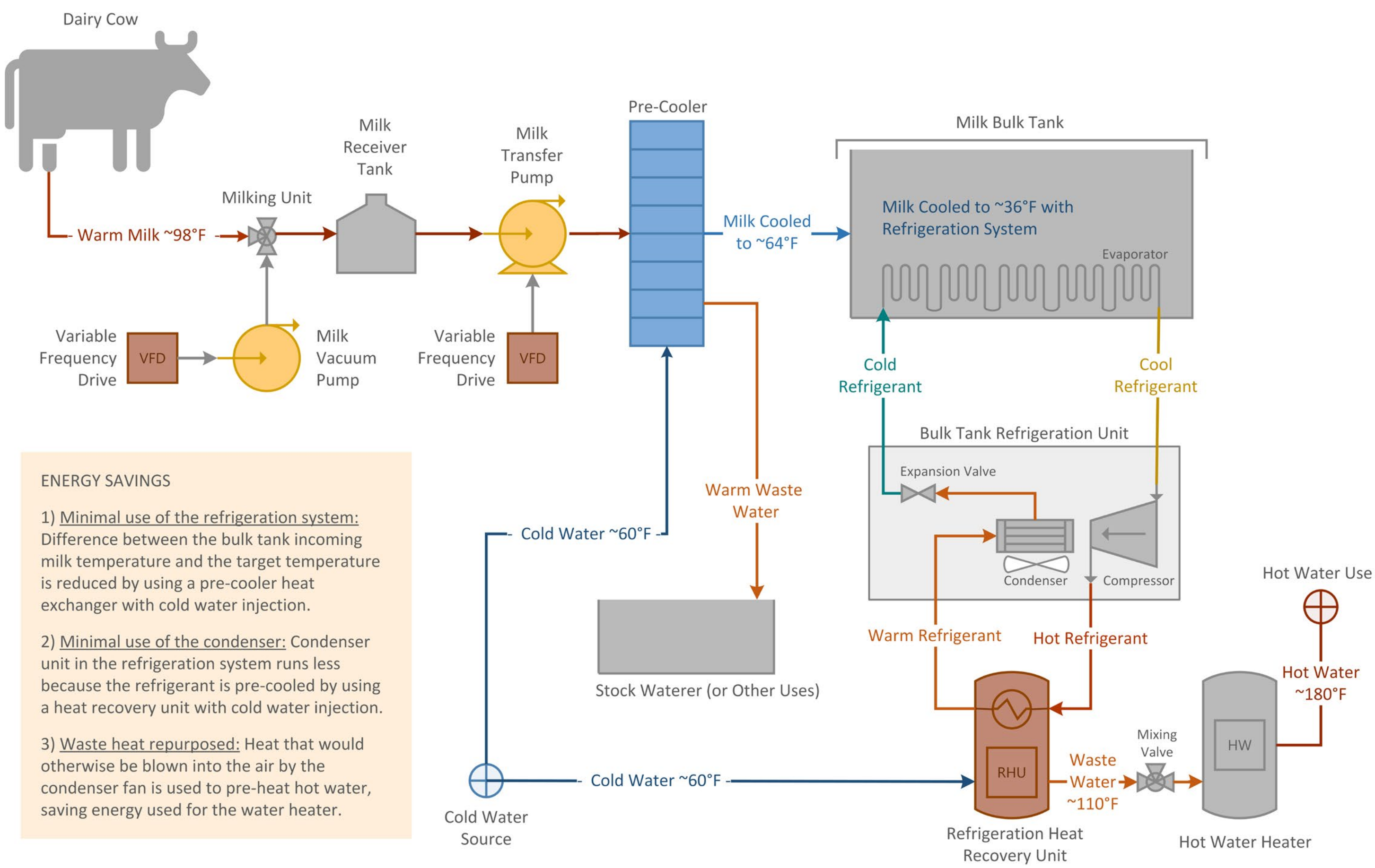
Milk Cooling and Storage

The milk cooling and storage process may offer the most significant opportunity for energy savings. Achieving these savings typically involves reconfiguring the cooling system design and adding equipment. Not all upgrades need to be made at once, but some need to be done together.

In an energy-efficient milk cooling system, the milk is not simply pumped into a refrigerated bulk storage tank. Instead, it is first pre-cooled with a high-efficiency in-line heat exchanger (typically a plate cooler using groundwater), which greatly reduces the amount of energy needed by the bulk tank refrigeration system. Once the pre-cooler is installed, the cooling system can be further optimized by installing a VFD on the milk transfer pump motor. The VFD will adjust the speed of the pump to maintain an optimal flow of milk to the pre-cooler, which improves its cooling efficiency. The transfer pump motor can also be replaced with a high-efficiency model to increase energy savings and may be needed for VFD compatibility. Refer to the Various Use Motors, Fans, and Pumps section for more information.

The bulk tank refrigeration system has two important opportunities for energy savings. If the refrigeration system utilizes an older type of compressor or condenser with reciprocating technology, replacing it with one that has a high efficiency scroll compressor will offer significant energy savings. Additionally, adding a refrigeration heat recovery unit to the compressor or condenser cooling system enables the capture of waste heat from the refrigeration process that can then be used for pre-heating water for the parlor hot water heater. Figure 3 shows the final configuration and components of an energy-efficient milk cooling and storage system.

Figure 3. Energy-Efficient Milk Cooling System.



Milk Cooling and Storage Equipment Upgrades – Key Considerations and Components

Milk Pre-Cooler: A milk pre-cooler can reduce energy use for milk cooling by up to 60%, extends the life the bulk tank refrigeration system, and cools milk quickly to reduce the risk of bacteria growth. The most often used pre-cooler type is the plate cooler, which consist of a series of stainless steel plates installed in the milk line between the receiving tank and bulk tank. Cold water passing through the plate cooler on one side of the plates absorbs heat from milk passing on the opposite side of the plates. Stainless steel plates are best to prevent corrosion from the milk, and the more plates in the cooler, the faster the milk will be cooled.

Pre-Cooler Size: Timely cooling and energy savings payback depend on getting an appropriately sized pre-cooler for the volume of milk processed in a day. Select a pre-cooler based on the maximum pounds of milk produced per hour, cold water input flow rating, and temperature of the cold-water supply. These factors are the key contributors to plate cooler efficiency. The cooling water input flow rate and milk flow rate should be about the same (1:1 ratio).

Pre-Cooler Cold Water Temperature and Flow Rate: The colder the water inlet to the pre-cooler, the more efficient it will be at cooling the milk. If a groundwater supply is available, that is ideal. Some pre-coolers also utilize a refrigerant in place of cold water, which is another option. Ensure the farm water system is capable of supplying water at the flow rate specified for the pre-cooler or select one that matches the flow rate. Water inlet pipe length and diameter need to be sized to accommodate the optimal flow rate as well.

Milk Transfer Pump Motor Controller: As the flow of milk to the cooling system changes with milking operations, the pumping rate required for a constant input of milk does as well. By adjusting the pumping rate with a VFD on the milk transfer pump motor, a steady rate of milk can be sent to the pre-cooler. This steady rate of milk flow is matched to the pre-cooler cold water flow rate, which optimizes the system's performance. Increasing the cold-water flow rate can be used to speed up heat exchange, and the VFD enables matching the milk flow rate. A level sensor is installed on the receiver tank for the VFD control input. A milk transfer pump VFD is only effective with a pre-cooler.

Milk Transfer Pump and Motor Type: Most transfer pumps are centrifugal type pumps, which are compatible with the VFD. The pump motor must be a three-phase AC induction type to be controlled by the VFD. Refer to the Various Use Motors, Fans, and Pumps section of this guide for more details.

Milk Transfer Pump Motor Efficiency: It may be worth replacing the pump motor with an energy-efficient model, such as a NEMA Premium® motor. If the motor must be replaced for VFD compatibility anyway, this is the standard practice. Refer to the Various Use Motors, Fans, and Pumps section of this guide for more information.

Bulk Tank Compressor/Condenser Type: Conventional bulk tank refrigeration systems utilize reciprocating type compressor/condenser units to circulate refrigerant through the cooling system. Updating to a high-efficiency scroll type or discus type compressor can reduce energy use by approximately 30%. These units utilize a built-in variable controller that matches the cooling requirements and typically run silently.

Bulk Tank Compressor Heat Recovery: Heat recovery is the process of utilizing waste heat from one process as a heat source for another process. The bulk tank refrigeration system typically utilizes one or more compressors to remove heat from the milk. Heat removed in this way is typically released into the air by compressor/condenser unit fans. This process can be modified with the addition of a refrigeration heat recovery unit that captures the waste heat and uses it to pre-heat water for other uses on the farm.

Refrigeration Heat Recovery Unit Size: As with parlor hot water heaters, the heat recovery unit tank size should be large enough to heat water required for one milking cycle. The tank should be installed as close to the bulk tank compressor unit as possible to reduce heat loss.

Low/No-Cost Options

System Maintenance: To maintain efficient operation and extend the life of the equipment, follow manufacturer recommendations for service including the following items:

- Pump and Motor Maintenance: Perform regular maintenance of the transfer pump and motor. Inspect and clean serviceable parts.
- Refrigeration System Maintenance: Clean and inspect the bulk tank refrigeration equipment regularly and fix any leaks or damaged components. This includes the condenser coils, evaporator coils, drain pan, fans, screens, grills, filters, and drier cores. Add or remove refrigerant as needed. As directed by the manufacturer, check and change the oil, filter, and inlet screen.
- Pre-Cooler Maintenance: Perform visual inspections and regular cleaning.

Pre-Cooler Water Recovery: Warmed water from the pre-cooler can be used for other uses, such as general purpose, cleaning, and livestock watering.

Milk Bulk Tank with a Built-In Refrigeration System.

Table 6. Typical Energy Savings for Milk Cooling System.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Install Milk Pre-Cooler*	20%–60%	$2,500–$25,000	3 years
Install Milk Transfer Pump VFD Controller**	5%–15%	$2,500–$5,000	4.5 years
Install High Efficiency Transfer Pump Motor	2%–5%	$3,000–$15,000	9 years
Install High Efficiency Bulk Tank Compressor	15%–20%	$4,500–$9,000	6 years
Install Refrigeration Heat Recovery Unit*	20%–60%	$2,500–$7,000	3 years

*For small farms (under 100 milking cows), USDA recommendations are to either install a pre-cooler or heat recovery unit but not both. This is based on the total installed cost and payback time for these units.

**Milk transfer pumps VFDs are only effective if a pre-cooler is installed.

Water Heaters

Water heaters can consume up to 20% of the energy used on a dairy farm. Heating water for washing and sanitizing milking equipment is usually the most intensive usage, but farms may also have general purpose water heaters. All water heaters should be considered for potential energy savings.

Having a properly sized, energy-efficient water heater is the most effective way to minimize water heating costs and may be worth replacing even if it is not at the end of its life. Another significant way to reduce water heating costs on a dairy farm is by installing a refrigeration heat recovery unit in the milk cooling system and connecting it to the water heater. This is discussed in detail in the Milk Cooling and Storage section of this guide. There are also several low- to no-cost opportunities for energy savings that can be implemented on any water heating system, old or new.

Water Heater Equipment Upgrades – Key Considerations

For cleaning milking equipment, dairy farms should use commercial rated water heaters to achieve temperatures required for sanitization.

Fuel Type: Investing in a new water heater can be an opportunity to switch to a lower cost energy source. Electric water heaters are more efficient and can use energy saving electronic controls. However, electric heaters may cost more to operate depending on local electric rates. In that case, the best option is a high-efficiency gas unit that utilizes electronic control.

Energy Efficiency: Water heater efficiency is rated by energy factor (EF). The higher the energy factor the more efficient the heating. If gas or oil is used, select a heater with an EF rating of 0.77 or more. If electric is used, look for an EF rating of 0.91 or more. An ENERGY STAR® rated water heater ensures it has a high EF.

Technology Configuration: There are many water heater options but they generally fall into these categories:

- Storage or Tankless: Storage systems utilize a water tank that continuously heats the volume of water in the tank throughout the day. Tankless systems use a high intensity heating element and coil system to heat only as needed. Tankless systems are more efficient because they are not affected by standby losses. Both storage and tankless system come in several configurations.
- Stand-Alone or Indirect: Stand-alone water heaters run independently of other heating equipment, while indirect systems (including tankless coil systems) are integrated with a heating system boiler. The indirect systems can provide heating efficiency in the winter but are very inefficient in the warmer months. Overall, a stand-alone system will typically offer more energy saving over time even if they cost more up front.

Technology Options: For use in an unheated barn, the standard tank style water heater or an on-demand heating system are the best options. For indoor applications, a heat pump water heater is also an option to consider. They are generally more expensive up front but will pay off over time in energy savings.

- On-Demand: On-demand water heaters are stand-alone tankless systems that are very efficient and effective if sized correctly. They are available in electric or gas, but because of the high-intensity energy required to heat water instantaneously, the electric units require a high amp rating on the electrical circuit, which may or may not be available on site. Both gas and electric are very efficient because they only use the electricity for a short time.
- High-Efficiency Tank: The standard tank style water heater comes in high efficiency models in both gas and electric. While not as efficient as heat pump or on-demand water heaters, they can still offer significant savings when replacing an older model and are very affordable.
- Heat Pump: Heat pump technology draws heat (and moisture) out of the surrounding environment (air or soil) to heat water. Geothermal or ground-source heat pumps systems are most efficient, but costly to install and require underground space. Air source heat pump hot water heaters are a good alternative. Although electric heat pumps use a storage tank, the heating technology allows them to be more efficient overall if sized correctly. They are only suitable for indoor use and basements are preferred because the pump can be noisy.

Tank Size: For tank systems, tank size should be determined based on how much hot water is typically needed at one time (typical usage). For example, in milk equipment washing, determine the water heater size by how many gallons of water are used per milking cycle. Also refer to manufacturer recommendations.

Water Pre-Heating Systems:

- Heat Recovery: This is the process of pre-heating water to the water heater from the waste heat of another process. On a dairy farm, the milk cooling process presents a great opportunity for heat recovery. This setup would be implemented in conjunction with milk cooling system upgrades and is discussed in detail in the Milk Cooling and Storage section.

Low/No-Cost Options

System Maintenance: Install a valve on the tank drain. When the tank is at a low water level, drain the remaining water for daily general-purpose uses. Completely empty the tank at least twice a year to reduce sediment buildup. Inspect and repair leaks on fittings and faucets.

Insulation: Insulating the water heater with a water heater jacket and installing pipe insulation on hot water lines reduces heat loss and water heater energy use for a very low cost. At a minimum, pipe insulation should be installed on the first 20 feet of pipe from the water heater. Electric water heaters can be fully insulated, while gas and oil heaters should not be covered near the hot flue.

Temperature Setting: For sanitizing and washing, water should be heated to between 180°F and 200°F. For general purpose uses, 120°F is recommended. Any higher than that is a waste of energy.

Water Conservation: Using less water is an easy way to save energy through energy conservation. Look for ways to reduce hot water usage without reducing cleaning effectiveness or adding process time.

High-Efficiency Gas Water Heater with Electronic Controls.

Table 7. Typical Energy Savings for Water Heater Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Install High-Efficiency Water Heater	10%–50%	$1200–$6500	5 years
Insulate Water Heater and Pipes	3%–4%	$0.5–$1.50/ft	12.5 years
Utilize Heat Recovery	20%–60 %	$2500–$7000	3 years

Online Water Heater Make and Model Energy Guide:

- https://www.ahridirectory.org (search by model number)
- https://www.energystar.gov/productfinder/product/certified-commercial-water-heaters/results
- https://www.energy.gov/articles/new-infographic-and-projects-keep-your-energy-bills-out-hot-water

Ventilation Fans

Ventilation in dairy barns serves two critical functions – air circulation and air exhaust. Both are essential for temperature regulation and air quality control. Cows are most comfortable between 25°F to 60°F, and most productive around 48°F. To keep cows happy and optimize production, they will require cooling during many months of the year. For their health, and the health of farm operators, air quality must also be managed to reduce airborne diseases, contaminants, moisture, and to ensure venting of manure gases to maintain sufficient oxygen levels.

The type and size of the barn will determine which ventilation system design is appropriate to achieve these objectives. For example, free stall barns with open sidewalls typically utilize circulation fans to aid in cow cooling and use natural ventilation from the open sidewall design for air exhaust. Enclosed barns, such as tie stall barns or free stall barns that are entirely enclosed with solid sidewalls, utilize an active exhaust fan system to provide the required cow cooling and exhaust requirements. Table 8 describes the primary ventilation strategies for dairy barns.

Barn ventilation should be thought of as a system with an ideal air exchange rate (number of complete air exchanges per hour). The volume of air in the barn (barn length x width x height, in cubic feet) determines the airflow rate (in cubic feet per minute) required to achieve this air exchange. The ideal air exchange rate and corresponding airflow changes seasonally with ambient temperature, but there are general minimums that can be used as a guideline.

Table 9 describes ventilation design goals with varying ambient conditions in a free stall barn. A well-designed ventilation system operates at (and not above) these values to achieve appropriate ventilation with as little energy use as possible. The use of adjustable speed fans, VFDs, thermostats, and airflow sensors enables this optimization. The maximum required air exchange rate is used for the overall system design to ensure adequate ventilation capacity on the hottest days.

Standard Circulation Fans in Open Air Free Stall Barn.

Table 8. Strategies for Dairy Barn Ventilation.

Ventilation System Design	Uses
Natural Ventilation Only	• Small- to medium-size open sidewall barns • Some air circulation control • Cooler climates • Seasonal use
Natural Ventilation with Circulation Fans	• Small to large size open sidewall barns • Some air circulation and some exhaust control • Cool to warm climates
Exhaust Fans with Louvers or Air Inlets	• Enclosed barns only, any size • Precise environmental control • All climates

Table 9. Optimal Ventilation Design for Open Free Stall Dairy Barn. Source: Gooch, C. 2008. "Dairy Free Stall Barn Design, a Northeast Perspective.

Guidelines for Optimal Dairy Barn Ventilation				
Ambient Temperature	Cold	Mild	Warm	Hot
Cubic Feet Per Minute (cfm)	100 cfm	200 cfm	500 cfm	1,000 cfm
Number of Air Exchanges Per Hour	6	12	30	60

Many variables affect airflow, exchange rate, and energy efficiency. This includes barn size and shape, fan configuration, fan size, fan performance ratings, and other factors. The barn ventilation system design will determine the number of fans required, as well as the size and performance parameters of the fans. These performance requirements will drive fan energy efficiency. As fan diameter increases, the efficiency of the fan typically increases as well. However, as with any motor-driven equipment, selecting fans designed for the performance range required will result in the most efficient operation. Fans of different manufacturers vary widely in efficiency so specifications and independent test data should be reviewed. Refer to the website link at the end of this section for the University of Illinois BESS Lab independent fan performance and efficiency tests for data on specific fan models.

A good system design can be achieved with a few key considerations, but for new barns, and bigger multi-barn operations, hiring a ventilation professional to perform an airflow analysis and ventilation system design will likely pay off in long-term energy savings.

Ventilation Equipment Upgrades – Key Considerations

Ventilation System Design: There are several standard ventilation system layouts used on dairy farms to achieve desired airflow and air exchange rates. The design depends on the type, shape, and size of the barn, and determine what type of fans will be used, how many are needed, and where they will be positioned.

- Overhead Circulation: For air circulation in free stall type barns with higher ceilings and an open barn design, vertically mounted overhead circulation fans are often used to continuously move air over the animals to keep them cool. With this type of barn natural ventilation of the open barn design provides air exhaust.
- Tunnel or Cross Ventilation: For air exhaust and circulation in enclosed tie stall type barns, fans installed on one end wall to pull air from air inlets on the opposing end wall are known as a tunnel ventilation design. This design requires a static pressure differential between the inside and outside of the barn so it must be an enclosed area. For wider barns, the same concept can be applied for a cross ventilation design in which the fans installed on one side wall to pull air across the barn from air inlets on the opposing side walls.
- Air Inlets: Properly sized and located louvers or air inlets are critical to achieving the desired airflow with tunnel and cross ventilation designs. They can be used in conjunction with pressure sensors to achieve precise airflow regulation. Size and location are determined by the cross-sectional area of the structure and fan specifications. Refer to fan manufacturer recommendations.

Fan Type - *Circulation, HVLS, and Exhaust Fans:*

- Circulation Fans: Standard circulation fans are typically 12 inches in diameter to 72 inches and utilize a simple design. These are typically spaced at 30- to 40-foot intervals in rows over the free stall and feed alley areas. The key performance specification for these fans is airflow, energy efficiency, and speed control.
- High-Volume, Low-Speed (HVLS) Fans: HVLS fans are ceiling mounted circulation fans with very long thin blades from 4 to 24 feet in diameter. These fans use little energy and one can replace many standard circulation fans, resulting in significant energy savings for spaces that are large enough. They are typically installed in free stall barns in a center line 50 to 70 feet apart, depending on their diameter.
- Exhaust Fans: Exhaust fans are large fans with a unique funnel shape that aids in their ability to suck air into an enclosed space through opposing wall inlets. The key performance specifications for these fans are airflow, static pressure performance, energy efficiency, and thermostat-based control.

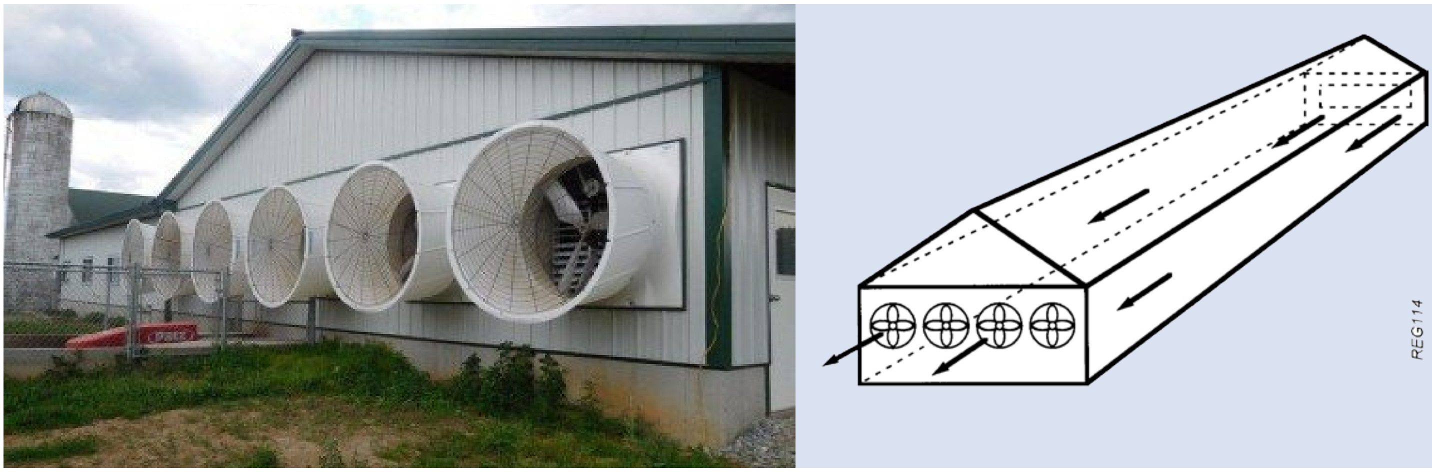
Fan Performance: Fan performance is typically specified as an airflow rate (measured in cubic feet per minute, cfm). The fan diameter, motor horsepower, and design affect how much air it moves.

Fan Diameter: Appropriate fan diameter depends on the desired air flow for each fan in the ventilation system. Airflow requirements depend on the size of the barn and seasonal air exchange requirements and can be calculated from barn air volume (barn length x width x height). Choosing the optimal fan size will minimize overall energy use because the fan will be operating in its best performance range.

Energy Efficiency: Fan efficiency is rated by the fan manufacturer. Exhaust fans are typical rated in cubic feet per minute per watt at a stated static pressure (cfm/watt @ SP). Circulation fans are typically rated in thrust per watt (lb/watt or lb/kilowatt). Fans of different manufacturers vary widely so specifications and independent test data should be compared. Overall efficiency is affected by fan diameter, blade design, motor design, and fan controls. Refer to BESS Lab independent fan performance and efficiency tests for data on specific fan models.

Fan Motor Controllers: *Variable Frequency Drives (VFD), Speed Controls, and Temperature-Based Control.* Fan motor controllers offer significant energy saving opportunities and include VFD, speed controls, and temperature-based controls. The controllers on the fans help farmers save energy by reducing the speed of the fans based on outside air.

- Fan controls can be used manually, on a time schedule, based on target temperatures, target airflows, or in some combination throughout the day and seasons.
- The best fans are capable of speed control by a built-in or third-party automatic controller such as VFD or speed controllers.
- Manual controls are an option as well and can be automated in the future.
- The type of controller to use depends on the type of fan motor and how the fan is being used.
- Refer to the Various Use Motors, Fans, and Pumps section of this guide for more information about motor compatibility and uses.



Tunnel Ventilation Design for Enclosed Tie Stall Barn. Photo credit: https://extension.psu.edu/tunnel-ventilation-for-tie-stall-dairy-barns.

Low/No-Cost Options

Natural Ventilation: Use natural ventilation whenever practical to aid in maintaining ideal temperatures and airflow.

Fan and Inlet Locations: Placement of fans and inlets can affect how well the ventilation system performs. Adjusting them to more optimal locations can help make them move air more efficiently.

Fan Settings and Controllers: Adding a compatible third-party fan controller to fans that do not have them can be a low-cost way to reduce energy use. Programming settings on fans with existing automatic controllers can also help save energy just like use of manual controls.

Fan Maintenance: Fans need regular maintenance to continue to perform at peak standards. Keep fans clean and properly lubricated to ensure maximum performance and minimal energy use. Fan blades coated with dust and debris move less air using more electricity. Lubricating shutters, tightening loose belts, cleaning air inlets, and removing debris caught in screens will improve fan efficiency.

Variable Frequency Drive for Fan Motor Control.

Table 10. Typical Energy Savings for Ventilation System Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Install High-Efficiency Circulation Fans	20%–35%	$600–$1,200	8 years
Install High-Volume Low Speed (HVLS) Fans	50%–65%	$4,000–$10,000	8 years
Install High-Efficiency Exhaust Fans	20%–30%	$900–$2,500	8 years
Install Automatic Fan Controls (all types)	5%–12%	$3,000–$15,000	3 years

Online Resources:

- University of Illinois Agricultural Fan Performance Tests: http://bess.illinois.edu/type.asp
- Penn State Extension Tunnel Ventilation System Design for Dairy Barns: https://extension.psu.edu/tunnel-ventilation-for-tie-stall-dairy-barns
- Wisconsin Public Service HVLS Fan Study: https://www.wisconsinpublicservice.com/savings/business/pdf/uwstudy.pdf

Various Use Motors, Fans, and Pumps

Electric motors that are inefficient or improperly sized can have a significant impact on total energy operating costs. Motor efficiency is a measure of how much total energy a motor uses to deliver the rated horsepower or torque to the motor shaft. Motors come in a variety of configurations and each design is optimized for different applications, can utilize different types of controls, and have varying energy savings potential. Selecting compatible equipment is an important part of the selection or upgrade process. Table 11 describes common motor technologies, corresponding controller compatibility, and energy saving upgrade options. Using motors with built-in controls or adding external motor controllers can offer significant energy savings but are only applicable to some uses. On dairy farms, ventilation fans and milk pumps may benefit from controllers depending on how they are being used. Other equipment may benefit as well but energy savings will vary and need to be evaluated.
For efficiency upgrades, typically motors that are used more than 2,000 hours annually are good candidates for upgrading in terms of cost-effectiveness.

All fans and pumps utilize a motor. Fans have integrated motors, while pumps have motors that may be built-in or a separate component. For applications in which fan speed or pump pressure can change as it is used, a VFD or speed controller on the motor can make them operate more efficiently by adjusting the motor speed to match the changing requirements. The fan and pump must be compatible with the motor controller to use them. For fans, this means that the fan motor is compatible, as shown in Table 11. For pumps, the pump itself also must be compatible. In general, rotary lobe type pumps, centrifugal pumps, and some sliding vane pumps may be compatible with control systems, while water ring and turbine type pumps would have to be replaced.

Manure Solids Separator Motor.

Choosing the right motor for a particular use on the farm will depend on performance requirements for that use which will influence motor size and technology choices. Energy efficiency for motors of all sizes and types are evaluated by two rating agencies, the National Electrical Manufacturers Association (NEMA) and the International Electrotechnical Commission. They work with motor manufacturers to certify and promote motors with energy efficiency. Selecting motors with these ratings ensure they have high-efficiency characteristics. Motor technologies are continuously being refined to increase energy efficiency throughout the range of sizes and performance requirements, particularly by using more advanced built-in electronic controllers or front-end circuits. While they are not the industry standard yet, they may be beneficial in some applications.

Table 11. Typical Motors Used on Farms.

Motor Technology	Size Range	Compatible Controller	Potential Energy Savings Upgrade
AC Induction Motor (single phase)	Typically < 10HP	None	• Upgrade to NEMA Premium® rated
AC Induction Motor (single phase)	All sizes	Variable frequency drive (VFD)	• Upgrade to NEMA Premium® rated • Add external VFD (variable load only)
Permanent Split Capacitor (PSC) and Other Small Motors	< 1HP	None	• Upgrade to ECM with optional speed controller
Electronically Commutated Motor (ECM)	< 1HP	Speed controller	• Add external speed controller (variable load only) • Manual speed controller

Motor Equipment Upgrades – Key Considerations

Motor Run Hours: If the motor is only running sporadically, replacement with a high-efficiency motor may not make economic sense. However, the longer the motor runs, the greater the potential savings. Typically, more than 2,000 hours annually is worth the investment. For any new installations, high-efficiency motors should be used.

Motor Size: Using a motor that is rated for the work it will perform is essential to achieving the best performance and energy efficiency. The amount of work a motor can perform is referred to as the motor load and is measured in horsepower (hp). Electric motors are typically designed to run best at 50% to 100% of their rated load, with maximum efficiency around 75%. Below 50% load, the efficiency dramatically decreases, so using a motor that is oversized will increase operating cost. Determining the load requirement for a particular use on the farm is a complex calculation and working with a motor dealer or manufacturer is recommended.

Motor Operating Environment: If the motor is used in an area that is wet or exposed to dust and debris, a motor with the dust tight or sealed housing may be needed. This may limit motor technology options.

Motor Efficiency and Ratings: Motor efficiency is a measure of how much total energy a motor uses to deliver the rated power to the shaft and typically specified as a percentage of energy conversion. The higher the percentage the more efficient the motor.

National Electrical Manufacturers Association (NEMA): NEMA certified motors are evaluated to a United States Department of Energy (US DOE) standard and are guaranteed to have high efficiency ratings. NEMA Premium® is the highest NEMA rating. NEMA rated motors also have high manufacturing quality standards so they will last longer with less maintenance cost and downtime. The International Electrotechnical Commission has comparable ratings to NEMA for motors manufactured in countries outside the United States.

Technology Options: There are many technology options and working with a motor manufacturer or dealer is the best way to select the right make and model for a particular use. The options listed below are broad categories with many configurations within each one but serve as a starting point for selection.

- Alternating current (AC) Induction: AC induction motors are versatile and available in many sizes and configurations. Depending on size, some can be connected directly to a utility wall outlet, while others (such as three-phase motors) must be connected to a utility junction box and installed by an electrician. While available for most farm uses, AC motors are typically not as energy efficient as DC motors. Three-phase AC induction motors can utilize an external variable frequency motor controller.
- Permanent Split Capacitor (PSC)/Other Small Motors: PSC motors are more efficient and simpler to maintain than AC induction motors but are limited in the amount of horsepower they can produce, typically less than 1 HP. PSC motors cannot accept external controllers.
- Electronically Commutated Motors (ECM): ECM motors are similar in size to the PSC motor (< 1HP) but are far more efficient motors and can be used with variable speed controllers. Some have controls built-in.
- Internal Combustion Engines (ICE): Motors that run on fossil fuels use internal combustion technology and are most useful for portable applications such as in tractors, field irrigation systems, or as a backup power source. These applications may have opportunities for energy savings by converting to an electric system, especially if the motor is oversized for its use. Regional fuel cost, utility rates, and electric motor technology are important factors in the energy cost savings associated with fuel conversions.
- Motor Controllers: For motor applications that have variable loads during usage and are not utilizing a motor that already has built-in controls (some ECM motors), adding a VFD or speed controller may be a significant opportunity for energy savings. These controllers automatically regulate the speed and rotational force as the motor load changes, which allows the motor to run more efficiently. VFDs are used with three-phase AC induction motors, while speed controllers are used with ECM motors.

Low/No-Cost Options

Motor Maintenance: Inspect and clean motors regularly to ensure optimal operation. Verify proper ventilation, check for loose connections, drain condensation, and lubricate bearings as applicable.

Motor Belt Type: Replace V-type belts with notched belts for better belt efficiency.

Engine Block Heaters Timer: For internal combustion engines, utilizing a block heater for cold weather starting, the addition of a timer to the heater can save significant energy costs. Program the timer to turn on the block heater a few hours before the equipment is needed instead of leaving it on overnight.

Manual Speed Controllers: Simple manual speed controls, such as those used for ventilation fans, offer a low-cost way to reduce energy use by turning down the motor speed when less power is needed.

Table 12. Typical Dairy Farm Motors Uses and Improvement Opportunities.

Motor Application	Area Used	Potential Improvements
Milk Vacuum Pump Motor	Parlor	High-efficiency motor upgrade (NEMA Premium® preferred)
		Install VFD motor controller
Milk Transfer Pump Motor	Parlor	High-efficiency motor upgrade (NEMA Premium® preferred)
		Install VFD motor controller
Ventilation Fan Motors **General Use Fan Motors**	Barn general Use	High-efficiency motor upgrade (NEMA Premium® preferred)
		ECM motor upgrade (< 1HP motors)
		Install VFD motor controller (3-phase AC induction motors)
		Install speed controller (< 1HP ECM motors)
Manure Scraper	Barn	Add manual controls (< 1HP ECM motors)
Manure Flush Pump Motor	Barn	High-efficiency motor upgrade (NEMA Premium® preferred)
Manure Solids Separator	Manure pit	High-efficiency motor upgrade (NEMA Premium® preferred)
		Install VFD motor controller (sand/manure separation)
Manure Pit Stirring Auger	Manure pit	High-efficiency motor upgrade (NEMA Premium® preferred)
Manure Pit Pumping	Manure pit	High-efficiency motor upgrade (NEMA Premium® preferred)
Grain Bin or Silo Loaders	Grain storage	High-efficiency motor upgrade (NEMA Premium® preferred)
Grain Dryers	Grain storage	High-efficiency motor upgrade (NEMA Premium® preferred)
Grain or Silage Augers	Grain storage	High-efficiency motor upgrade (NEMA Premium® preferred)
Irrigation Pump Motors **Other Pump Motors**	Crop fields general use	High-efficiency motor upgrade (NEMA Premium® preferred)
		Install VFD motor controller (3-phase AC induction motors)
		Install speed controller (< 1HP ECM motors)
		Fuel conversion to electric
Water Circulation Pump Motors (Boiler Heat/Hot Water/Other)	General use	High-efficiency motor upgrade (NEMA Premium® preferred)
		ECM motor upgrade (< 1HP motors)
Tractor Engine	General use	Install block heater timer

Table 13. Typical Dairy Farm Motors Uses and Improvement Opportunities.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Replace Small Motors (<1 HP) with ECM	65%–75%	$150–$250	3 years
Replace AC Induction Motor with NEMA rated	2%–5%	$500–$15,000	9 years
Install Motor VFD Controller on 3PH AC Induction Motors with Variable Loads	50%–80%	$500–$15,000	3 years
Install Timer on Internal Combustion Engine Block Heaters	65%–90%	$30–$50	1 year
Replace Internal Combustion Engine with an Electric Motor	20%–50%	$2,500–$25,000	4.5 years

Online Motor Selection and Energy Guides:

- NEMA Standard Motor Manufacturers https://www.nema.org/directory/manufacturers
- VFD Saving Calculator http://www.vfds.org/vfd-savings-calculator.html

Stock Waterers

In northern climates, keeping animal drinking water from freezing in unheated barns and outdoor settings can be a challenge. Traditional stock waterers use 1,000- to 1,500-watt electric heaters that run continuously, which produces a significant opportunity for energy savings. Newer stock waterers utilize better insulation, groundwater temperature, solar radiation and have been proven to keep drinking water from freezing using as little as 250 watts of electricity or no electricity at all. A unit with thermostat control will shut the unit off when the water is at the right temperature to keep it from freezing and adds to energy savings. Figure 4 shows an ideal setup for an energy free watering system. It utilizes an automatic underground water source, drinking values that keep the water in the insulated storage tank when not needed, and a concrete slab to prevent soil erosion and compaction from the cows.

Stock Waterer Equipment Upgrades – Key Considerations

Size: The most important factors for successful use of reduced and no energy stock waterers is choosing the right size waterer for the number of animals that will be using it. This is particularly true for the energy-free waterers, which rely on the water circulation that occurs when the animals drink from the waterer. For either type of waterer, refer to manufacturer specification to choose the right size for the number of animals.

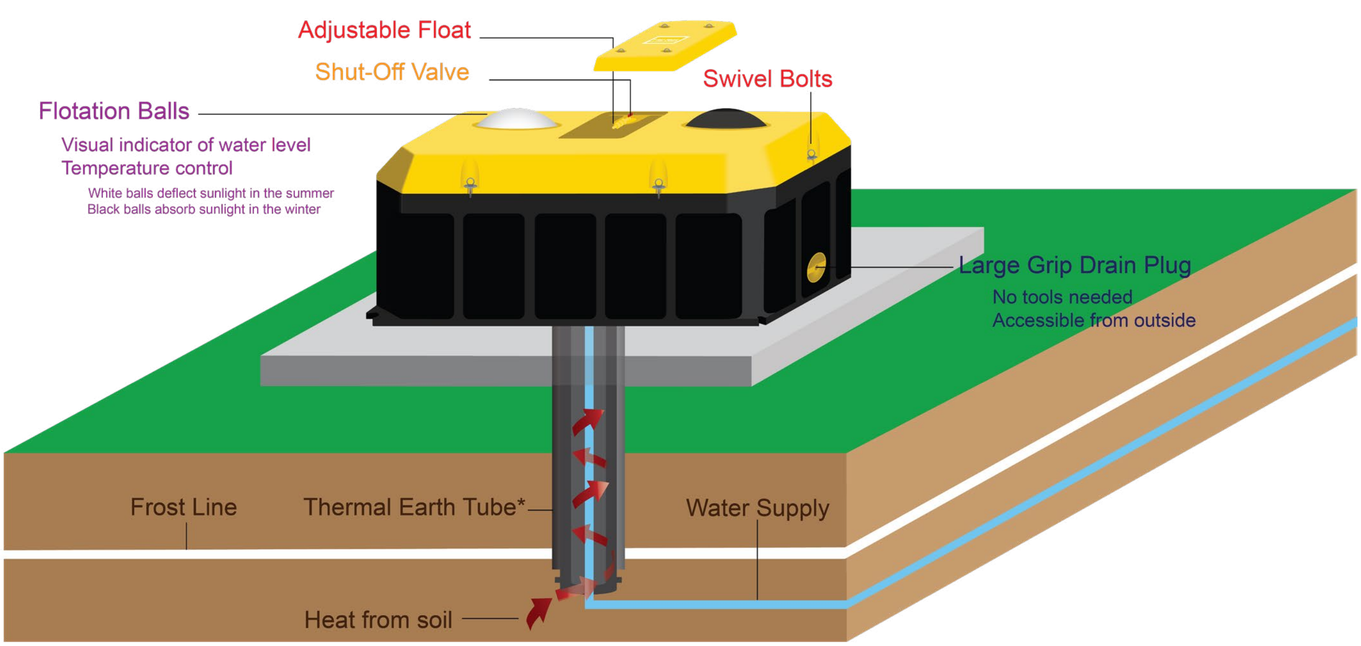
Technology Options:

- Low Energy Stock Waterer: Newer waterer designs have incorporated better insulation to reduce heat loss, which reduces how much energy is required to keep the water from freezing. They utilize a fully enclosed, insulated water reservoir with a floating plastic cover the animal must touch to get the water out. Many include an automatic refill float valve that allows more water in when the reservoir is below a certain level. For an automatic system, the water lines to the waterer need to be deep enough to prevent freezing and should be well insulated.
- Energy Free Stock Waterer: Energy-free waterers utilize a dry well or riser pipe that is installed deep enough in the ground to take advantage of underground geothermal heat, which stays at a stable, above-freezing temperature year-round in any climate (45°F to 75°F, depending on location). Like the low-energy versions, they utilize an enclosed, insulated water reservoir and have an automatic refill setup. Energy free waterers are typically not recommended for smaller herds because they rely on water circulation from the animals drinking to keep from freezing. System manufacturers can provide that information.

Temperature Control: Installing a waterer with a thermostat will provide additional and significant energy savings by automatically turning the heater on and off as needed.

Safety: When installing electric waterers, wiring should be covered (ideally in conduit) and properly grounded to avoid electric shock to the animals or operators. This should be done in a manner appropriate for a high-traffic area. Removable electric heaters should be cleaned annually to remove sediment and bacteria.

Figure 4. Energy-Free Automatic Stock Waterer. Credit: [Tru-Test Datamars](#).



*To prevent your vertical water supply line from freezing, an insulated thermal earth tube is installed under the ground during set-up.

Low/No-Cost Options

Location: Locating waterers in areas that are protected from wind and snow will reduce heat loss and increase energy savings. It will also help if the waterer can be located behind one or more walls.

Insulation and Covers: Building an insulated box around any waterer will help reduce heat loss. For non-covered waterers, an insulated cover could be fitted with a small hole for drinking.

Maintenance: Waterers are often out in the elements and, therefore, require regular attention during colder months when they are most needed. Check and clean the drinking float to be sure they are not leaking and keep it from freezing. Check for and repair leaks on pipes and in the reservoir. Repair and add insulation as needed. Check thermostats and refill valves that are operating properly. For safety, check wiring and ground connection for damage and repair as needed.

Settings: For waterers with thermostatically controlled heating elements, the optimal energy-saving yet effective heating temperature is 32°F to 34°F.

Table 14. Typical Energy Savings for Stock Waterers.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Install Low-Energy or Energy Free Stock Waterer	40%–100%	$350–$1,000	3.5 years

Building Heating

Building heating systems can be optimized to achieve energy savings and increase comfort. Simple, low-cost efforts like insulating, sealing, and installing automatic temperature controls can go a long way. When it is time to upgrade a space heating system, there are many options to choose from. Existing system fuel source, efficient rating, and heat output should be determined so a more energy-efficient and, if possible, renewable energy-based replacement can be chosen. Space heating systems should be chosen by how they will be used since some heating technologies are more appropriate for specific applications. Table 15 describes some space heating options and their uses on the farm. Some of the more efficient choices are pictured in Figures 5 and 6, which are described in the Building Heating Equipment Upgrades information box.

Table 15. Example Space Heating Technologies and Uses.

Technology	Fuel Type	Mechanism and Function	Where Used
Ceramic Infrared Radiant Heater	Gas	Infrared radiation from heating element through the air	Outdoor spaces for localized heat
Condensing Unit Heater	Electric, gas, biomass	Fans blow air over heated metal elements to warm and distribute it, sometimes through heating ducts	Closed spaces of any size
Boiler	Electric, gas, biomass	Hot water pumped through pipes and heat radiated into surrounding air	Closed spaces of any size
Heat Pumps	Electric	Refrigerant cycle used to heat or cool air or water, sometimes circulated in ducts or pipes.	Small to medium areas, in addition to other heating systems in colder climates
Air Curtains	Electric	Physical barrier created by blown air	Large openings between heated and unheated spaces
Strip Curtains	N/A	Physical barrier typically made of plastic strips	Large openings between heated and unheated spaces

Figure 5.Condensing Heating Unit for Closed Spaces.

Figure 6. Ceramic Infrared (IR) Radiant Heater for Open Spaces.
Credit: Solaronics, Inc.

Building Heating Equipment Upgrades – Key Considerations

Fuel Type: Heaters typically use fuel oil, gas, biomass, or electricity. Investing in a new heating system can be an opportunity to switch to a lower cost, cleaner, or renewable energy source. Electric heaters are usually more efficient, provide opportunities for energy savings with electronic controls, and are typically lower maintenance. However, they can cost significantly more to operate depending on electric rates. The next best options are typically high-efficiency gas heaters with electronic controls, or clean-burning biomass systems, such as wood pellet boilers.

Heating Medium: Heaters use water, air, or metal fins to release heat into open spaces. Each heating system utilizes one or a combination of these heating mediums. Each offers different characteristics in terms of comfort and area they can effectively heat. Switching from one medium to another when upgrading equipment may add to installation costs.

Heating System Controls: All heating systems should include thermostat controls to automatically turn off the units when the target temperature is reached. Schedule-based temperature settings and remote controls can also be utilized to reduce temperature targets as appropriate through the day and seasons. When using a combined heating and cooling system, set the heating and cooling targets several degrees apart so the unit does not run continuously.

Heater Efficiency: Heater efficiency is often rated with a coefficient of performance (COP or CP) specification which is the ratio of heating to energy used. A heater with high COP means it is a more efficient system.

Technology Options: Each space heating option utilizes a different fuel source and heating medium. The appropriate fuel source and heating medium is different based on the type of application. Below is a list of the most efficient choices for dairy farms.

- Ceramic Infrared (IR) Radiant Heaters: There are several types of IR heaters available for various applications. The variety that are most appropriate for dairy farms are the high intensity, fast-acting ceramic IR heaters that can be used for localized heat in open spaces, such as over the milking pit in a parlor that is not well sealed. This option provides comfort to workers without investing in heating the entire room. These heaters use gas to heat a quartz heating element and radiate infrared heat. They are very energy-efficient units.
- Condensing Unit Hot Air Heater: Condenser units utilize a powerful fan that blows air across a heated metal element, which simultaneously heats and distributes the air into the open space. The most energy-efficient condenser units typically use natural gas or propane to heat the metal element. They also extract heat from the exhaust air and circulate it back into the system. With these features they achieve combustion efficiency of 93% or greater. Condenser units are sized for the space to be heated and can effectively be used to heat some or all of an enclosed space.
- Boiler Systems: Boilers are appropriate for closed spaces of any size. They use gas, oil, biomass (such as wood pellets), or electricity to heat water. The water is then circulated in tubes around the building and the heat radiates into the air around them. The boiler unit consists of a water heater, water circulation pump, and exhaust fan (gas/oil only). Opportunities for energy savings in a boiler system include using a high-efficiency boiler unit and utilizing boiler water pre-heating from heat recovery systems.
- Heat Pumps: Heat pumps are highly efficient and are appropriate for heating and cooling in small- to medium-sized spaces. When used by themselves, they are most effective for heating in climates with mean annual temperatures above 30°F; however, they can be used along with another heating system in colder climates to increase heating efficiency. They can also be used to provide efficient air cooling in warmer months.

Low/No-Cost Options

Insulation and Sealing: Sealing leaks around windows, doors and other openings in a closed building are simple ways to reduce energy loss. Sealing and adding insulation to the roof cavity is effective in stopping heated air from circulating out of the building. Insulating walls will also help reduce heat loss.

Boiler Water Heater: Insulating the water heater with a water heater jacket and installing pipe insulation on hot water lines reduces heat loss and water heater energy use for a very low cost. At a minimum, pipe insulation should be installed on the first 20 feet of pipe from the water heater. Electric water heaters can be fully insulated, while gas and oil heaters should not be covered near the hot flue.

Settings and Controls: For a small investment, programmable thermostats offer a significant opportunity to save energy by allowing temperatures to be set on a schedule that makes sense for farm operations. Turning the temperature down by just a few degrees can make a big difference. For combined units that heat and cool, set the heating and cooling targets several degrees apart to create a neutral zone so the units do not run continuously. In the barns, cows do best between 25°F to 60°F.

Strip Curtains: Strip curtains are soft plastic curtains used in doorways and openings between heated and non-heated areas or cooled and non-cooled areas to minimize air exchange. On a dairy farm they are a low-cost option for containing heat from a closed parlor to an open barn area.

Air Curtains: Air curtains are installed between heated and non-heated areas to minimize infiltration. They serve the same purpose as strip curtains but instead of a physical barrier, they are machines that blow a wall of air downward into the openings to create a barrier to the heated air.

System Maintenance: Regular equipment maintenance reduces energy costs and extends equipment life.

- Gas and Oil Heaters: Annual checkups for gas and oil heaters should include cleaning air filters and exchangers; a flame check or combustion test for burning efficiency; inspection and cleaning of fuel filters, nozzles, and valves; inspection, alignment, and lubrication of fan motor, belts, and bearings (as applicable). A blue flame indicates a clean burn and yellow indicates insufficient air.
- Boiler Water Heater: To reduce sediment buildup, which leads to inefficient operation, the boiler water tank should be emptied regularly. Install a valve on the tank drain, and when the tank is at a low water level, drain the remaining water for daily general-purpose uses. Completely empty the tank at least twice a year. Inspect and repair leaks on fittings and faucets.
- Thermostats: Metal contact on older style thermostats can be off by many degrees and will perform better, and more accurately, if they are annually cleaned and recalibrated. Electronic thermostats do require cleaning.

Table 16. Typical Energy Savings for Building Heating Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Upgrade to High-Efficiency Space Heaters	5%–30%	$500–$10,000+	7.5 years
Install Air Curtains	~30%	$250–$1500	3 years
Install Strip Curtains	10%–40%	$100–$250	3 years
Install Insulation and Sealing	3%–15%	$1.50–$2.50/ft	3.5 years
Install and Program Temperature Controls and Schedules	5%–12%	$500–$15,000+	4.5 years

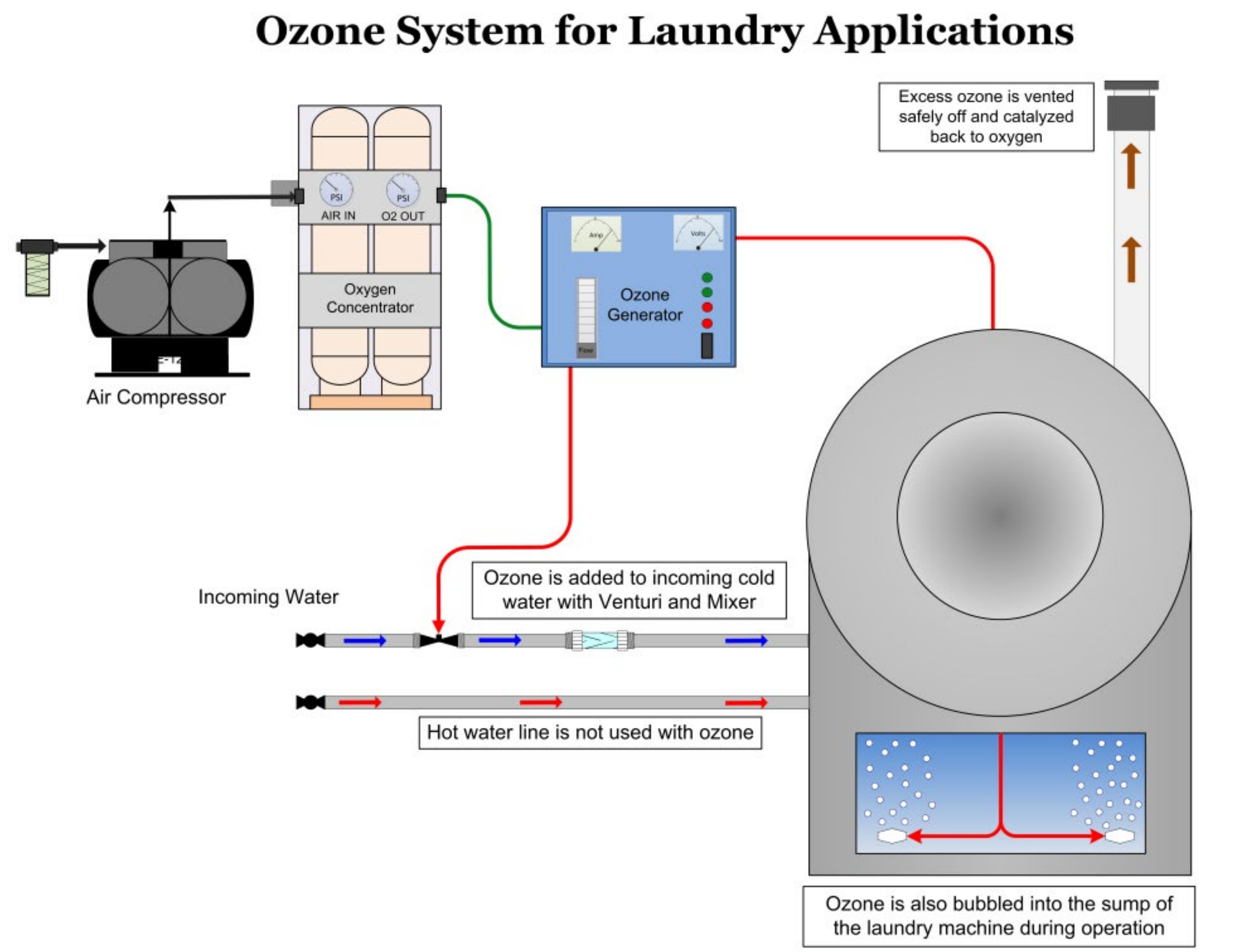
Washing Machines

Energy-efficient washing machines, ozone laundry systems, and reduced temperature detergents are a few ways to reduce water and energy usage for dairy laundry.

For commercial washing machines, an ozone laundry system offers a big opportunity for energy savings. Ozone machines are widely used in the hospitality sector and utilize ozone gas (made from oxygen) instead of heat and detergent to clean and disinfect, as shown in Figure 7. This technology reduces hot water usage associated with laundry by 80% to 100% and overall water consumption by about 25%. It also reduces the amount of chemicals used for cleaning and kills viruses and bacteria more effectively than bleach. Other non-energy benefits include reduced drying time.

For commercial and residential size washing machines, high-efficiency Energy Star® rated washing machines and dryers are a good option and readily available. Commercial machines are better at water extraction than residential units, so it reduces the amount of energy needed for drying and costs as well. Ozone laundry system add-on devices are available for both to further reduce energy and water use.

Figure 7. Ozone Laundry System. Credit: Oxidation Technologies, LLC.



Low/No-Cost Options

System Maintenance: Ozone laundry systems require regular checks to ensure that ozone levels remain below acceptable limits and cleaning is effective.

Reduced Temperature Detergent: Reduced temperature detergent decreases the amount of energy required to heat cleaning water by up to 50% while also reducing wear on washer components.

Washer Settings: Utilize washer eco-modes and only use hot water to wash when required for sanitization. Utilize shorter wash cycles when appropriate.

Table 17. Typical Energy Savings for Washing Machine Improvements.

Improvement Recommendation	Annual Savings Range (% of energy cost reduction)	Total Installed Cost Range ($)	Typical Payback (years)
Commercial Ozone Washing Machine	~40%	$2500–$3500	1 year
Commercial High-Efficiency Washing Machine	~25%	$6000–$12000	6.5 years

Online Washing Machine Make and Model Energy Guide:

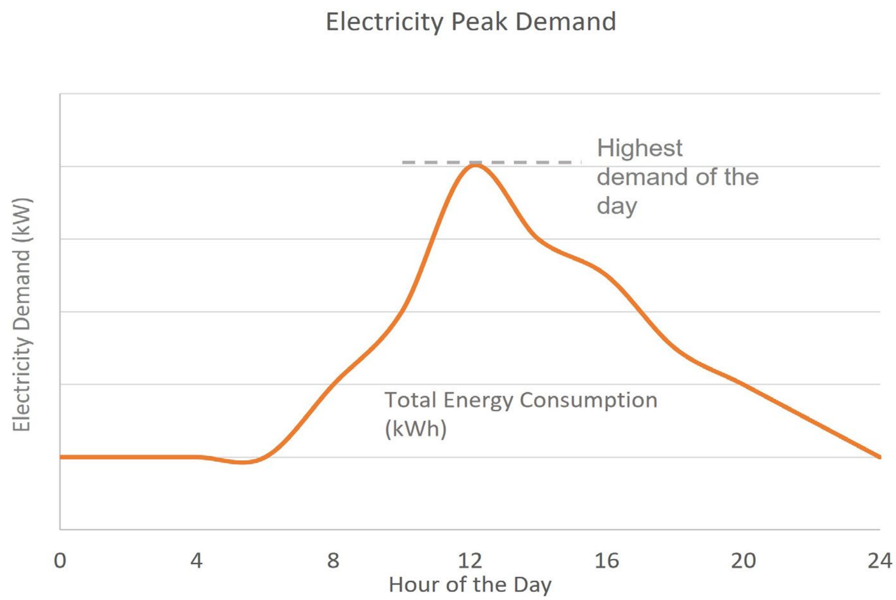
- https://www.energystar.gov/products

Time-of-Use Management

Electric peak demand is the instantaneous amount of electricity that is being used at any given time, measured in kilowatts (kW). Electric utilities are concerned about peak demand because they must maintain power quality with appropriate equipment and power supply capacity to meet their peak load. Peak demand is typically monitored on a moving 15-minute average each month. To pay for the generation and transmission capacity to meet peak demand, utilities may charge energy users a fixed demand charge based on the single highest 15-minute demand period measured per month (or some other specified period).

As shown in Figure 8, demand is different than actual electricity consumption. Consumption is the actual usage of electricity, measured in kilowatt hours (kWh). Some utilities have consumption rates that vary throughout the day based on the time of day when the peak occurs. This is known as time of use rates. Higher rates are associated with periods of the day when the utility sees higher demand across all users on the grid.

Figure 8. Example Electric Utility Peak Demand Curve for One Day.



Since electricity demand is based on when energy is used, there may be opportunities to reduce individual demand charges by better managing the time at which equipment is used. This is what is referred to as time-of-use management. A review of electric utility rate structures will determine if rates vary throughout the day and what peak demand value the farm is being charged for. Comparing that to what time of day farm equipment is running will determine if there are opportunities for savings.

By running equipment during off-peak hours and reducing your peak energy requirement, energy costs can often be considerably reduced. Examples include shifting irrigation to late evening hours or staggering the use of high-energy equipment (such as heaters, fans, and milk pumps) to reduce peak power draw.

Renewable Energy

Renewable energy refers to an energy source that is continuously replenished in a short amount of time. Energy from the sun, wind, water, or biological processes is considered a renewable resource. Specific renewable energy technologies include biodigesters, solar photovoltaics, solar thermal, geothermal, hydro, wind turbines, and more.

There are often several opportunities for renewable energy systems on farms to meet at least some of the farm energy needs; however, the energy production potential is very location specific. Renewable energy systems often require significant investment as well. Before undertaking these projects, energy use should be minimized through conservation and efficiency projects, such as those described in this guide. In this way, the renewable energy system design is only as big as it needs to be. Once energy efficiency measures are installed, a renewable energy assessment or feasibility study should be conducted at the farm site to fully understand the project economics (considering tax credits, depreciation, operation and maintenance costs, and available incentives), and local utility grid regulations.

Figure 9. Dairy Farm Solar Photovoltaic Renewable Energy Production.

Typical renewable energy projects on dairy farms include biodigesters that use methane gas from cow manure to generate electricity and heat, and solar photovoltaic (PV) systems for producing electricity. PV systems can be mounted on the ground, or a rooftop as shown in Figure 9. A roof mounted system takes advantage of existing infrastructure so it may cost less, but ground-mounted systems can be more optimally placed for sun exposure and energy production. They can be built so cows can still graze underneath them and benefit from the shade, or so that crops can grow underneath them. Most renewable energy systems are scalable and can be used at any size operation. Small systems not connected to the electric grid can sometimes be utilized in remote areas.

Farmer Resources

Programs and Project Funding Opportunities

There are several resources for a farmer interested in accessing assistance or funding for energy audits, feasibility studies, energy efficiency, and renewable energy projects. Below is a summary of each of the resources currently available to New York farms. It is best to check with these agencies and programs directly as funding availability and program offerings are subject to change.

NYSERDA Agriculture Energy Audit Program

NYSERDA offers technical assistance to identify energy efficiency measures for eligible farms and on-farm producers, including dairies, orchards, greenhouses, vegetables, vineyards, grain dryers, and poultry or egg farms. Farms can request the level of energy audit that best fits your farm's needs. NYSERDA will assign a Flexible Technical (FlexTech) Assistance Consultant to visit your farm and perform an energy audit at no-cost. Farms must be customers of a New York State investor-owned electric utility and pay the System Benefits Charge (SBC). Please check your farm's current utility bills for eligibility.

Table 18. NYSERDA Agriculture Energy Audit Types.

Audit Level	Audit Activities	Type of Report that the Farm Receives
Comprehensive	Detailed energy audit	Energy audit report with calculated evaluations of appropriate energy efficiency measures including simple payback; meets ANSI/ASABE S612 standards
Targeted	Energy audit focused on specific systems, energy efficiency measures, or renewable energy	System-specific energy analysis report

These energy audits provide an overview of your current energy usage and make efficiency project recommendations based on those findings, as well as recommending other farm energy goals. The farm's previous year's utility bills are used along with existing equipment specifications and run-time information to complete the analysis. Site visits are conducted to inventory existing equipment and systems currently in use. A comprehensive audit report provides a list of recommended improvements with associated energy and cost savings and anticipated payback period, while a target audit analyzes specific systems or can evaluate renewable energy system cost effectiveness.

Once the audit is completed, a NYSERDA Agriculture Energy Audit Program representative will review the audit with you and answer any general questions about the report and recommendations. The representative also assists with identifying financial incentives, rebates, and grants to support moving forward with any projects.

For more information on No-Cost NYSERDA Energy Audits for New York State Farms visit nyserda.ny.gov/All-Programs/Programs/Agriculture-Energy-Audit, email aeep@nyserda.ny.gov or call 1-800-732-1399.

NYSERDA Commercial New Construction Program

NYSERDA may provide technical and financial support to applicants or their design teams to identify and install energy efficiency, beneficial electrification, and carbon reduction opportunities. The program's goal is to achieve Carbon Neutral Ready levels of performance in non-residential and mixed-use new construction, change of use, and substantial renovations to existing buildings. A carbon neutral building is one where the design, construction, and operations do not contribute to emission of greenhouse gases that cause climate change.

The Commercial New Construction Program is available for eligible customers to design and build projects that achieve Carbon Neutral Ready levels of performance in new construction, substantial renovations, and change of use for commercial, industrial, and institutional buildings in New York State.

Get in touch at NewConstructionProgram@nyserda.ny.gov.

New York State Utility Programs

All commercial customers, including dairy farms, are eligible to apply for incentives from their New York State investor-owned electric utility.

National Grid Customers

www.nationalgridus.com/Upstate-NY-Business/Energy-Saving-Programs/Agri-business-program

Upgrade your equipment or plan an expansion with the help of our energy efficiency incentives and grant opportunities. Call 855-236-7052 or email energysavings@nationalgrid.com to discuss the opportunities for your agri-business.

NYSEG and RG&E Customers

For a complete list of eligible upgrades, view our rebate catalogs at www.nyseg.com/cirp or www.rge.com/cirp. Prescriptive Rebates are available for barn fans, milk pre-cooling equipment, milk refrigeration heat recovery, and vacuum pumps for milk extraction. Call 888.316.8023 or email at CIenergysavings@franklinenergy.com

Orange and Rockland

www.oru.com/custom, www.oru.com/prescriptive

Rebates and incentives for energy-efficient upgrades. Contact a representative for more information. Call 1-877-434-4100 or email at dlenergyefficiencyprograms@coned.com.

Central Hudson

www.cenhud.com/my-energy/save-energy-money/business-incentives/

Contact us with questions at CHGEPrograms@icfi.com or 800-515-5353. Our program staff are available to discuss your project and assist.

ConEdison

https://www.coned.com/en/save-money/rebates-incentives-tax-credits/rebates-incentives-tax-credits-for-commercial-industrial-buildings-customers

The Con Edison Commercial & Industrial (C&I) Energy Efficiency Program offers incentives for installing energy-efficient electric and gas equipment and technologies. Energy efficiency can help improve the bottom line by reducing energy use and maintenance costs while increasing operating efficiencies. These upgrades can also help protect the environment. Email applications to commercial@coned.com.

United States Department of Agriculture (USDA)

Natural Resource Conservation Service (NRCS)

Environmental Quality Incentives Program

https://www.nrcs.usda.gov/wps/portal/nrcs/main/ny/programs/financial/eqip/

NRCS offers financial assistance and technical assistance to help agricultural producers and other landowners address resource concerns and maintain conservation improvements on their land. NRCS' Environmental Quality Incentives Program On-Farm Energy Initiative helps farmers and ranchers make voluntary improvements that can boost energy efficiency on the farm. Since the program's inception in 2009, farmers across the nation have received benefits from upgrading equipment, including reduced input costs, increased productivity per unit of energy consumed by equipment and lighting, and reduced air pollutants and greenhouse gas emissions caused when energy is generated for agricultural use.

Rural Development

These programs offer funding to complete energy audits, provide renewable energy development assistance, make energy efficiency improvements, and install renewable energy systems. Rural Development has programs that help convert older heating sources to cleaner technologies, produce advanced biofuels, install solar panels, build biorefineries, and much more. USDA Rural Development is at the forefront of renewable energy financing, with options including grants, guaranteed loans, and payments.

Value Added Producer Grant

https://www.rd.usda.gov/programs-services/value-added-producer-grants

Provides grant funds for planning and working capital expenses to help agricultural producers enter value-added activities.

Rural Energy for America Program (REAP)

Rural Development provides grants and loan guarantees for renewable energy installations and energy efficiency improvements to existing facilities or processes through REAP.

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