Connecticut Farm Energy Program

CONNECTICUT
FARM ENERGY PROGRAM

Energy Best Management Practices Guide

ctfarmenergy.org

CONNECTICUT FARM ENERGY PROGRAM

A program of Connecticut Resource Conservation & Development Area, Inc., with support from USDA Rural Development and the Connecticut Department of Energy and Environmental Protection.

Introduction

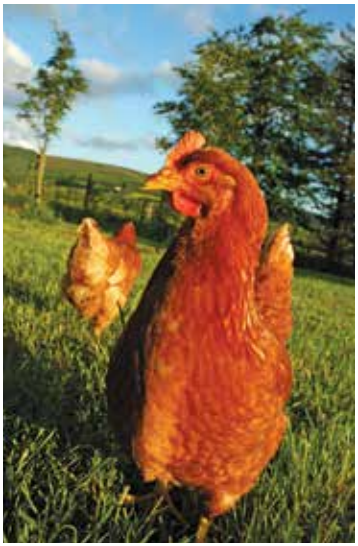
Welcome to the Connecticut Farm Energy Best Management Practices Guide. This guide is intended for all Connecticut farmers who are interested in reducing their energy costs. Inside, you will find a mix of low-cost or no-cost tips you can implement immediately, plus information about equipment upgrades you may wish to consider.

A farm energy audit can help you further determine which equipment is the best choice for your operation. An audit will include an estimate of how much energy and money you can save with specific equipment based on your usage patterns and costs. At the end of this guide, you will find resources for an energy audit, as well as funding sources to help cost share energy efficiency and renewable energy upgrades to you farm.

This guide was developed by EnSave, Inc. on behalf of the Connecticut Farm Energy Program (CFEP) which is a program of Connecticut Resource Conservation & Development Area, Inc., with support from USDA Rural Development and the Connecticut Department of Energy and Environmental Protection. Past project support has been provided by the U.S. Department of Energy and the Connecticut Department of Agriculture. CFEP works in partnership with Energize CT (administered by Eversource, United Illuminating, Southern Connecticut Gas, and Connecticut Natural Gas), CT Energy Efficiency Board, Eversource, United Illuminating, CT Green Bank, UConn Extension, USDA-Natural Resources Conservation Service (NRCS), Connecticut Farm Bureau, New England Farm Energy Collaborative and other related organizations. Funding for this Best Management Practices Guide was made possible by a USDA Rural Development RBDG Grant.

CFEP serves as a clearinghouse of information both on assistance and funding for energy projects as they relate to AG producers and

AG based small business across Connecticut. CFEP aims to provide information as it pertains to energy and agriculture in Connecticut through the CFEP website, email updates, publications, workshops and events it hosts and participates in.



CFEP serves as a resource of information on energy in relation to grant opportunities, loans, audits, educational opportunities and events for AG producers and AG based small business located in Connecticut.

CFEP also provides technical assistance in the form of grant writing to eligible Connecticut AG producers and rural small businesses in applying for USDA Rural Development REAP (Rural Energy for America Program) Grants. REAP Grants which are part of the Farm Bill, provide assistance to those who are eligible with Energy Efficiency and Renewable Energy projects.

The Mission of the Connecticut Farm Energy Program is to provide technical assistance to AG producers and increase awareness about energy conservation & efficiency while promoting alternative & renewable forms of energy on Connecticut Farms.

For more information about the program, please visit the Connecticut Farm Energy website at CTFarmEnergy.org.

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Acknowledgements

The *Connecticut Farm Energy Best Management Practices Guide* was prepared by EnSave, Inc. on behalf of the Connecticut Farm Energy Program.

Guidance and support in reviewing this manual during the course of its production was provided by Connecticut Resource Conservation & Development Area, Inc., USDA Rural Development, USDA Natural Resources Conservation Service, Connecticut Department of Agriculture, Energize Connecticut, Connecticut Green Bank and Working Lands Alliance.

COVER AND BACK PHOTO: PETER TAVINO

Definitions

ENERGY AUDIT: An energy audit is a document that analyzes the current energy use on an operation and recommends cost effective measures to increase energy efficiency. The audit report will contain a description of your farm's current baseline usage for various systems, specific recommendations to increase energy efficiency, and an explanation of the energy and cost savings you can expect from the recommendations. The American Society of Agricultural and Biological Engineers has a Standard for Conducting On-Farm Energy Audits; you should ensure any auditor for your farm is following this standard.

ENERGY ASSESSMENT: An energy assessment can mean different things to different people. To some, an assessment is synonymous with an audit, while others consider an energy assessment to be more basic than an energy audit. If you are considering an energy assessment, make sure you understand the scope of work involved.

FEASIBILITY STUDY: Before undertaking a costly project such as installing an anaerobic digester or a solar array, you will generally receive a feasibility study conducted by a renewable energy professional. This study will identify the potential for renewable energy on your farm, and will detail the costs of the system and expected payback. A feasibility study is an important step to ensure you are aware of the risks and benefits of a large investment such as renewable energy.

ENERGY CONSERVATION: Energy conservation refers to using less energy by changing a behavior. An example is turning off the lights when you leave a room, or turning down your thermostat. You have reduced your energy use, but you have also changed the amount of light or heat available to you. This guide contains many recommendations for energy conservation. Generally, conservation activities are low or no-cost, but may not save as much energy as efficiency measures.

ENERGY EFFICIENCY: Energy efficiency refers to using less energy by changing equipment. If you replace your lights or furnace with a more

The American Council for an Energy Efficient Economy has a good primer on energy efficiency at https://smarterhouse.org.

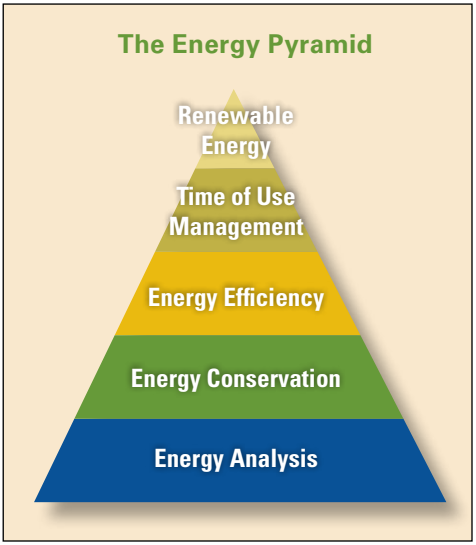
efficient model, you have reduced your energy use without changing the amount of heat or light available to you. This guide contains many recommendations for energy efficiency. Generally, energy efficiency measures have a cost, but the cost is worthwhile due to higher energy savings.

RENEWABLE ENERGY: Renewable energy refers to an energy source that can be replenished, such as energy from the sun, wind, earth, or water. Non-renewable energy sources, such as coal or oil, rely on a finite source of raw materials.

ENERGY PYRAMID: EnSave's Energy Pyramid provides a useful way to consider energy management on your farm. Starting at the base of the pyramid, with energy analysis, ensures you know what energy management tools you need before making an investment. The pyramid begins with the easiest and most cost-effective option, and gradually works its way up to the most complex and expensive options. Following the pyramid ensures you have considered the opportunities in each step before moving on to the next one.

Reading this guide, or undergoing an energy audit is a good first step of energy analysis. Following your analysis, consider energy conservation and then energy efficiency. Once you have saved all the energy possible through those means, consider time-of-use management, or using energy at specific times in order to reduce load on the electric grid.

Finally, consider renewable energy once you have ensured you have saved energy in other ways. This keeps you from using renewable energy to power an inefficient process. EnSave designs and implements agricultural energy efficiency programs and provides energy audits.



Dairy

Dairy farms have among the highest energy use of all types of agriculture. Fortunately, there are many technologies dairy farmers can implement to significantly reduce their utility bills. Many of these technologies can also have an effect on cow comfort and the noise level in the barn. Most Connecticut dairy farms are smaller than the national average, but many energy efficiency opportunities are still cost effective on small to medium sized dairies.

Variable Speed Drive (VSD) on the Milking Vacuum Pump

VSD OPERATION

Milking vacuum pumps are sized to deliver the required maximum vacuum level to operate the milking and washing systems. Occasionally, when a milking unit falls off a cow's udder or when there is a temporary system leak, high levels of vacuum are needed for short intervals. Normal milking operation uses less than half the maximum vacuum available.

Before variable speed technology was used for vacuum pumps, dairy operators had to run their pumps at a constant high speed to perform adequately during the occasional short intervals of high vacuum need. The VSD determines exactly how much vacuum the system requires and regulates the speed of the pump. The result is a pump that runs at a much lower speed most of the time and requires substantially less electricity to do the job.

STABLE VACUUM

A constant vacuum level at the milking units is necessary to prevent bacteria from accessing the cows' teats. A VSD reacts quickly and maintains a stable level as well or better than conventional systems.

EQUIPMENT LIFE

A motor run at full speed will have a shorter life span than a motor that regularly runs at a lower speed. Since the VSD operates the vacuum pump at reduced RPMs, bearings and other internal components last longer and require less frequent maintenance. Pumps will require less frequent replacement.

NOISE REDUCTION

Conventional milking vacuum pumps running at full speed make a lot of noise, yet with a VSD installed the noise level is dramatically less because the motor is operating at slower speeds for most of the milking. Many farmers benefit from significantly quieter milking areas.

GREAT FINANCIAL INVESTMENT

The energy and cost savings from installing a VSD varies from farm to farm, based on the size and type of vacuum pump, the type of milking system, and the milking time. Depending on the site, energy savings from installing a VSD can offset installed costs in as little as two years. Quick payback makes the VSD one of the best investments a dairy farmer can make.

Milk Pump Variable Speed Drive

VALUE OF MILK PRE-COOLING

The speed of milk flow to the bulk tank is an important consideration in the milk cooling system design. Milk pre-cooling is widely used to maintain milk quality by cooling the milk quickly, reducing bulk tank compressor run time, and saving on electricity costs. Plate-type milk pre-coolers utilize cold water in a heat exchanger to absorb heat from the warm milk before it goes to the bulk tank. The efficiency of the plate cooler depends on the temperature of the cold water, the ratio of cold water to warm milk flowing through the unit, and the rate of flow of the milk. Plate coolers are sized to accommodate the volume of milk being pumped to the bulk tank.

HOW DOES A MILK PUMP VARIABLE SPEED DRIVE WORK?

Another factor in plate cooler efficiency is the flow rate of milk through the unit. A variable speed drive (VSD) on the milk transfer pump maximizes plate cooler efficiency by providing a steady, even flow of milk though the heat-exchanger to maximize heat exchange efficiency.

SIGNIFICANT SAVINGS

Manufacturers' tests have shown an average energy savings of 30% on the run time of the bulk tank compressor when the milk pump is controlled by a VSD with a plate cooler.

WHY SHOULD I INSTALL A VSD ON MY MILK PUMP?

Your milk will cool faster due to a constant flow rate through the plate cooler. Also, faster milk cooling inhibits growth of bacteria, preserving milk quality and flavor. Plus, lower bacteria counts often deliver higher milk premiums. Shorter compressor run times mean lower electric bills.

Ventilation

NEED FOR VENTILATION

Heat and moisture build-up in confined areas can adversely affect the health of animals and humans. Manure gases can contribute further to poor air quality. Research has shown that inadequate barn ventilation can result in a production drop of 6 to 14 pounds of milk per cow per day.

VENTILATION REQUIREMENTS

Barn ventilating systems need to accomplish the following tasks:

- Removal of excess moisture produced by cow confinement.
- Cooling of milking animals during warmer months. A heat-stressed cow produces less milk.
- Removal of noxious gases from manure pits under or near barns.

APPROACHES TO VENTILATION DESIGN

Different strategies can be effective for different locations and structures. Some barns are equipped with side "curtain walls" that can be opened up in warmer weather and closed for winter months. Other barns feature open end walls. "Greenhouse barns" with transparent roofs can create natural air circulation. Some structures feature an open ridge vent roof design.

Most agricultural ventilating systems rely on exhaust fans to remove moisture build-up. A common goal is to provide four complete air changes in the barn per hour. Properly sized and located air inlets are necessary for an effective and efficient system. Research indicates that milk production is optimized at an ambient air temperature of about 48 degrees Fahrenheit. For cow cooling in warmer weather, ventilation

design depends on structural characteristics. In rectangular tie stall barns, "tunnel ventilation" has proved effective in producing air circulation. For larger free stall barns with higher ceilings, overhead circulating fans, mounted vertically, are generally used to keep air moving over animals.

Fan output is measured in cubic feet per minute (cfm). The size, horsepower, and design of the fan all affect how much air it will move. Cfm output also depends on the static pressure of the building. Static pressure is the force of air against the outside of the building that inhibits exhaust air. Electrical efficiency of a fan is rated in cubic feet per minute per watt (cfm/watt) of electricity. It is important to select high efficiency equipment. Fans of different manufacturers differ markedly in air delivery and energy efficiency. Tests of 36-inch exhaust fans recorded air varying from 6,400 cfm to 13,000 cfm. Energy efficiencies ranged from 8.3 to 18.6 cfm/watt. Fan blades coated with dust and debris move less air using more electricity.

VARIABLE SPEED DRIVES

Similar to the VSDs used during milk pumping, VSDs used in conjunction with ventilation fans can offer significant savings to farmers depending on their existing ventilation requirements. As temperatures fluctuate during the day, the optimal ventilation rate for maximum cow comfort also changes. The volume of air produced by a fan is directly related to the revolutions per minute of the fan. By reducing the speed of the fans to only supply the volume of air necessary for maximum cow comfort, significant energy savings are possible. For example, when fan speed is halved using a VSD, the power consumption of the fan drops to 1/8 of the original consumption.

Dairy Lighting

THE VALUE OF PROPER LIGHT LEVELS

Proper lighting is necessary for worker safety and comfort and can improve worker efficiency. It is an important consideration in the planning, construction, or maintenance of dairy facilities. In recent years, the prices of high-efficiency light emitting diode (LED) lights have dropped significantly. Substantial energy and cost saving opportunities are available when switching from incandescent, fluorescent or high-intensity discharge (HID) light fixtures to LED lighting.

COST EFFECTIVE ENERGY EFFICIENT LIGHTING

Factors affecting efficiency include amount of light per watt and lamp life. Occasionally LED lighting systems are more expensive to purchase than incandescent, fluorescent or HID fixtures, however, the energy cost savings combined with longer lamp life offset these higher initial costs for energy-efficient lighting systems.

SELECTION CRITERIA

Other characteristics to consider when selecting a lamp type are starting temperature and warm-up. LED lights perform well at cold temperatures (-20°F). The minimum starting temperature for most fluorescent lamps is 50°F. Ballasts are available that allow fluorescent lamps to start at -20°F, but costs are higher than for standard ballasts.

LED lights do not have a warm-up period. Standard fluorescent lamps have a slight starting delay, but by using quick-start ballasts, the time can be reduced. All HID lamps have a warm-up period, which can range from one to 15 minutes. Pulse-start metal halide lamps boast shorter start time and lower total fixture wattage over most HID fixtures. High-output LED fixtures are also a viable alternative to traditional HID lighting and produce more high-quality light at lower wattages than traditional HID fixtures such as high-pressure sodium. LED fixtures, previously untested for use in dairy applications, have quickly become the standard for new lighting projects or when upgrades are being considered.

On the next page are recommended illumination levels for various areas of the dairy. The unit of illumination is the "footcandle," (f-c) which is defined as one lumen falling on each square foot of work area. A lumen is a measure of the rate of flow of light from a source such as a lamp or the sun. These recommended illumination levels can be met with various types of lamps. When analyzing lighting systems, the most important characteristics are light quality and energy efficiency. The quality of the lighting installation is influenced by the color of the light, light uniformity, glare, and reflection of the surfaces in the room.

Recommended Dairy Illumination

MILKING PARLOR
General Lighting:
20 footcandles (f-c)
Operator's Pit: 50 f-c

MILK ROOM
General Lighting: 20 f-c
Washing Area: 100 f-c
Bulk Tank Interior: 100 f-c
Loading Platform: 20 f-c
Utility/Equipment Room: 20 f-c
Holding Area: 10 f-c

TREATMENT & MATERNITY AREAS
General Lighting: 10 f-c
Treatment or Surgery: 100 f-c
Office: 50 f-c
Feeding area, tie-stall barn: 10 f-c
Feeding area, free-stall barn: 20 f-c

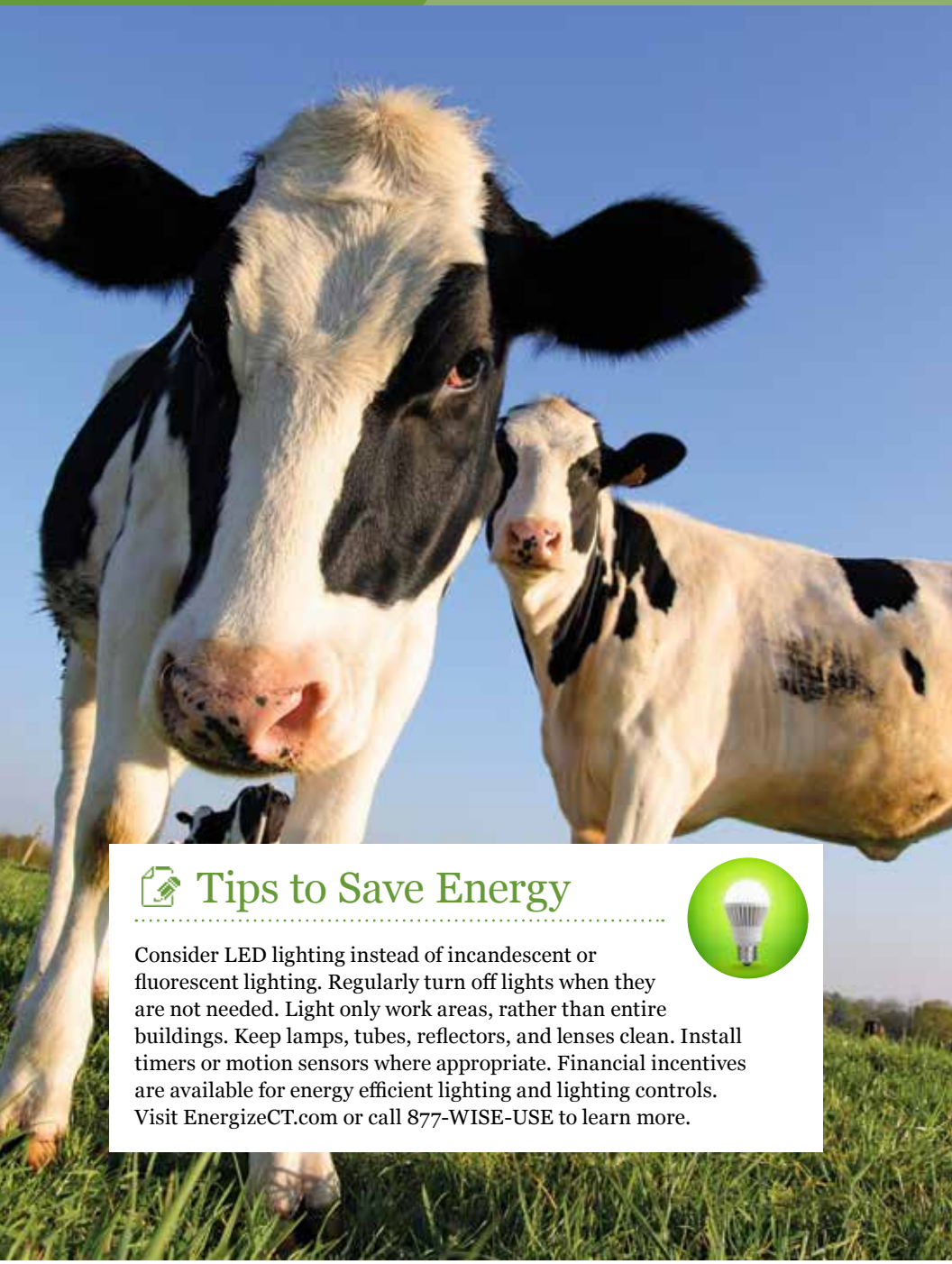
Heating

WATER HEATING

Water heating can consume as much as 20% of the energy used on a dairy farm. Having the properly sized water heater will help minimize water heating costs. Heaters should be chosen based on how much hot water is needed over a specific period of time. On dairy farms, this is usually how many gallons per cycle are required for the milking system and bulk tank. When considering a new water heater, consider a model that is ENERGY STAR® rated to ensure the equipment operates at the highest possible efficiency. Typically, this means choosing a unit with the highest energy factor (EF) rating for the fuel type used on the farm. 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.

OZONE LAUNDRY

If you need a commercial-sized washing machine in your parlor, consider installing an ozone laundry system. An ozone laundry system uses ozone gas instead of heat and detergent to clean and disinfect laundry, reducing hot water usage associated with laundry by 80% to 100%, and reducing overall water consumption by about 25%. An ozone laundry system also reduces the use of chemicals used for cleaning and kills viruses and bacteria better than bleach. Other non-energy benefits include savings in labor and drying time.



Tips to Save Energy

Consider LED lighting instead of incandescent or fluorescent lighting. Regularly turn off lights when they are not needed. Light only work areas, rather than entire buildings. Keep lamps, tubes, reflectors, and lenses clean. Install timers or motion sensors where appropriate. Financial incentives are available for energy efficient lighting and lighting controls. Visit EnergizeCT.com or call 877-WISE-USE to learn more.

SPACE HEATING

Rather than heating the air, radiant tube heaters use radiant energy to efficiently heat the objects in a space. If the milking parlor is heated during the winter months, a radiant tube heater positioned above the parlor pit is an option to consider for worker comfort. This option is appropriate for the milking parlor because they are often poorly sealed and have many areas for heated air to escape.

Solar Thermal Systems can be a cost-effective solution to heating (or pre-heating) water, especially during the warmest months of the year. Using no fuel except sunlight, solar collectors can be mounted on south-facing roofs or on ground-mounted racks adjacent to the building where the hot water is needed. Generally speaking, a supplemental water heater will be needed to insure adequate hot water during winter months or cloudy days, but a properly-sized solar thermal system can cost-effectively provide 40% or more of your hot water needs. Like all renewable energy systems, the economics are most favorable when there is a steady, fairly predictable need for hot water over the course of the year, such as on a dairy farm.

Since solar thermal systems produce at least 60% of their annual output in the six summer months (and can be adjusted to produce an even higher percentage), they are optimally suited to situations that require more hot water in the April – September time frame than in the winter months. Significant energy savings in water heating can also result from compressor heat recovery systems.

Compressor Heat Recovery

HOW DOES COMPRESSOR HEAT RECOVERY WORK?

The process of cooling milk in a bulk tank or with a chiller utilizes one or more compressors to remove heat from the milk. Heat removed in this fashion is typically released into the air by condenser fans. A compressor heat recovery unit captures this "waste heat" and uses it to pre-heat water. Sometimes this removal actually improves compressor performance as well. A compressor heat recovery unit looks like a water heater tank and is capable of raising cold water to very warm temperatures of 110°to 130°F.

ENERGY SAVINGS

With a compressor heat recovery unit in place, the water heater has much less work to do. Since the incoming water is already preheated the electric or gas-fired water heater gets less use, and it is likely to last longer as well. Often a compressor heat recovery unit is the most cost effective piece of energy saving equipment that can be installed on a farm.

EXAMPLE

A dairy farm uses 225 gallons of 160-degree water each day to wash milk lines, milking units, and the bulk tank and to mix calf feed. Their well water temperature is 55 degrees. They have a 120-gallon electric water heater and they pay $0.10 per kilowatt-hour (kWh) for their electricity. The farm will save 13,780 kWh and $1,378 each year by installing compressor heat recovery. Larger operations can expect to see even greater savings.

BENEFITS OF COMPRESSOR HEAT RECOVERY UNITS

- Can cut water heating costs by 50–75%, depending on the farm's size
- Extends the life of the refrigeration system
- Cools milk faster
- Improves long term milk storage
- Producers often see a payback in less than five years

Milk Pre-Cooler

HOW DO MILK PRE-COOLERS WORK?

In a milking operation without milk pre-cooling, the milk comes from the cow at about 98°F, flows into a receiver, and is then pumped to the bulk tank. Compressors cool the incoming milk in the bulk tank to a storage temperature of about 38°F. The milk pre-cooler, often called a plate cooler, is a series of stainless steel plates installed in the milk line before the bulk tank. Cold water passes through a plate cooler in one direction and absorbs heat from the warm milk pumped through the plate cooler in the opposite direction. The plate cooler can reduce the temperature of the milk entering the bulk tank to within 4°F of the incoming cold water temperature.

PERFORMANCE FACTORS

Milk pre-cooler effectiveness depends on several factors. Colder water

removes more heat than warmer water. The ratio of water volume to milk volume moving through the plate cooler also affects performance. Setting up the cooler to use twice as much water flow as milk flow is common. The greater the ratio, the more pre-cooling occurs. A third factor is the velocity of the milk moving through the cooler. The slower milk goes through the plate cooler, the more heat can be removed.

ENERGY SAVINGS

Milk cooling costs are usually one of the largest energy operating expenses for dairy producers. For example, a dairy farm that produces 3,000,000 pounds of milk per year and uses 112,000 kilowatt hours (kWh) of electricity at a cost of $0.10 per kWh can save as much as $800 (8,000 kWh) a year if a plate cooler is installed.

NON-ENERGY BENEFITS INCLUDE:

- Extends refrigeration equipment life by reducing load and run time.
- Increases milk quality by inhibiting bacterial growth through faster cooling.
- Saves electricity and money with faster cooling and shorter compressor run time.
- Increases milk production, which can also be realized when the warm water exiting the Pre-Cooler is used for stock watering.

SPECIAL CONSIDERATIONS

Work with your equipment dealer to ensure that your water supply meets your cooling needs. Water used in Milk Pre-Coolers must meet all local Health Department quality requirements.

Scroll Compressor

Dairy producers know the importance of cooling their milk quickly and keeping it cool until it is picked up. For many years reciprocating compressors have cooled milk in America's bulk tanks. Whether single or double acting, these reciprocating compressors historically have used a lot of electricity, required regular maintenance, and tended to be very noisy. It is now possible to replace an aging reciprocating compressor with a newer scroll compressor and experience several benefits from the switch.

USES LESS ENERGY

Scroll compressors require much less current than conventional reciprocating compressors and are even able to run on single-phase electricity. One study found that a 3-hp scroll compressor used 42.1 percent fewer kilowatt-hours than a 3-hp reciprocating compressor over a 36-day period (72 milkings).

RUNS MORE QUIETLY

Working in the milk house will be easier on your ears. Since there are only four moving parts (no pistons or discharge valves), scroll compressors run at lower decibel levels and vibrate less than reciprocating compressors. Under load the scroll compressor is quieter than a household clothes washer (approximately 65dBA with enclosure).

MORE DURABLE AND RELIABLE

With only four moving parts and no metal-to-metal contact, there are no seals to tear and no lubrication needed. Another important feature is that scroll compressors operate well in cool weather and do not require crankcase heaters. Finally, scroll compressors can start under any system load so there is no need for a start kit.

BETTER CONTROL OVER MILK QUALITY

It is crucial to keep milk cooled at a consistent temperature to prevent high bacteria counts. A scroll compressor delivers the consistent, dependable cooling necessary to sustain low temperature conditions in the bulk tank.

COMPETITIVELY PRICED AND EASILY AVAILABLE

Several manufacturers produce scroll compressors and are sold through farm and dairy equipment suppliers. Installation costs are comparable to conventional reciprocating compressors.

Energy Efficient Stock Waterers

THE NEED FOR RELIABLE STOCK WATERING

All livestock need access to drinking water. In northern climates keeping water from freezing in unheated barns and outdoor settings is critical. This need has usually been met by heating drinking water with an electric heater that often draws 1000 to 1500 watts.

THE ENERGY EFFICIENT ALTERNATIVE

Well insulated, plastic stock waterers have proven their ability to keep drinking water from freezing using 250 watts of electricity or even no electricity at all. One of the keys to making the energy-efficient and energy-free models work is proper sizing for the number of animals served. Since ground water temperature is usually around 50° F, it must drop about 20°F to reach the freezing point. If enough animals drink from the waterer, the incoming "warm" water will keep the unit from freezing. Proper insulation of the unit keeps this heat in the waterer. Many of these units have floating plastic covers which float on the water and seal the opening of the watering reservoir when animals are not drinking. Not all sites are suitable for energy-free models. It is particularly important to assure that electrical wiring not come in contact with livestock drinking water to prevent electric shock to animal or farmer.

Did You Know?

Several factors determine how much water a cow will drink: her size, milk yield, quantity of dry matter consumed, temperature of the environment as well as the water quality, availability of the water, and amount of moisture in her feed. For horses, bison, and other livestock, a primary waterer selection factor is the frequency of use. With minimal usage the waterers need to be better insulated and equipped with reliable heaters to ensure the floating cover does not freeze in place, preventing the animal from drinking.

Greenhouses

A grower can save a substantial amount of energy by implementing steps to reduce heat loss in the greenhouse. Greenhouse energy savings can also be found by upgrading lighting, motors, refrigeration, and ventilation. While many Connecticut greenhouses are only used for a portion of the year, it may still be worthwhile to implement some of these steps. An energy audit or audit pre-consultation can better determine which actions are most cost effective for your particular situation.

Heating

TEMPERATURE MANAGEMENT

Many energy efficiency opportunities in greenhouses involve optimizing the heating and cooling systems. Proper management of the temperature inside a greenhouse is critical to avoid over or under-heating, and to ensure efficient use of whatever fuel is used to heat the space. In all cases, growers need to consider the effect planned changes to the greenhouse will have on plant health.

INFRARED PLUS ANTI-CONDENSATION TREATED FILMS

A combination infrared / anti-condensation treated film is a best choice for the inner layer of polyethylene film. While polyethylene film helps to retain heat, the condensation that forms on the inside reduces light and solar radiation and can affect plant health. Many times, a grower can see a reduction in heating energy use between 10 and 20 percent, and payback periods can be less than two years even if the greenhouse is only heated for a few months.

GREENHOUSE ENERGY CURTAIN

Installing an energy curtain to the ceiling of a gable or arch greenhouse can result in significant heating energy savings. The curtain closes off part of the ceiling, creating an attic space. This conserves heat in three ways:

- It creates an insulating air layer between the curtain and the roof
- It reduces the volume of air in the greenhouse that needs to be heated
- It reflects the radiated heat back into the greenhouse

INSULATED SIDE WALLS

Adding foam insulation to the side walls, end walls, and perimeter of a greenhouse can result in heat energy savings. The insulating foam can be a one or two inch foam board, or spray foam. In either case, the foam should have a protective cover to prevent deterioration. If the foam is on the inside of the walls, it should have a reflective coating aimed to the inside in order to reflect the solar radiation back into the greenhouse.

SEALING AIR LEAKS

Holes and cracks, even small ones, can add up to significant heat loss and money wasted. Pay particular attention to doors, windows, and any point where the greenhouse cover attaches to the foundation or walls. Be sure to seal any leaks with caulk or weather stripping.

POLY FILM COVER ON GLASS HOUSES

A seasonal or permanent layer of poly film on your glass greenhouse can reduce heat loss. However, it can also lead to faster depletion of carbon dioxide and increased humidity. Consult with an energy efficiency expert or your local extension agent before placing a poly film cover on your greenhouse.

WIND BREAKS

If your greenhouse is located in an open, windy area without protection from wind, consider installing a temporary or permanent wind break. Wind breaks reduce infiltration losses from the prevailing winter wind. A temporary wind break can be a 10-12' snow fence located 40 to 60 feet away from the greenhouse. To create a permanent wind break, plant a mix of coniferous and deciduous trees about the same distance from the greenhouse.

ELECTRONIC THERMOSTAT

Consider an electronic thermostat that can be programmed to automatically adjust the temperature throughout the day. This provides for greater precision and greater efficiency. No matter what thermostat you are using, keep it clean and make sure it is recalibrated annually for optimum accuracy.

CONDENSING UNIT

Consider replacing old forced air units with higher efficiency condensing units. Condensing unit heaters are more efficient than other unit heaters. They burn at higher temperatures and have a secondary heat exchanger that captures heat from the water vapor in the exhaust stream from the latent

heat. These units are usually made of higher quality materials to resist corrosion since they need to handle the condensate. As such, they work well for greenhouses. These heaters are available for natural gas or propane heating.

ROOT ZONE HEATING

Transitioning heating from over-head to under benches (placed under the floor or in the floor) can save a significant amount of energy and increase the growth rate of plants. Since the plants are being heated at the roots, the temperature of the air in the greenhouse can be lower by up to 10°F. This is possible because the temperature at the roots is more critical than the temperature at the leaves for achieving plant growth. These systems can reduce the fuel required for heating by as much as 10%, but under-bench heating have some significant additional costs that should be considered. Usually some Forced Hot Air (FHA) units are still necessary for colder climates to keep snow and ice off the roof and keep plant foliage from freezing. Systems with hydronic heating will have costs for piping, hot water storage, control systems, and boilers.

RADIANT HEATING SYSTEMS

Radiant heating systems are more efficient than other heating methods such as forced air or baseboard heating. Radiant systems work by radiating heat from a hot surface into the cooler surroundings. In greenhouses, this is often implemented by running hot water pipes under the foundation of the greenhouse. As hot water is circulated through the

pipes, heat is radiated into the greenhouse space above the floor. These systems provide uniform, gentle heat resulting in fewer cold spots, which allows plants to thrive.

BIOMASS BOILERS

Biomass gasification boilers are available as a continuous burn and an on-demand burn. A continuous burn system burns a load of fuel continuously until the fuel is gone and transfers the heat to a water storage system. An on-demand burn system uses the thermal mass of the firebox to maintain high temperatures so that combustion can occur when heat is needed. A storage system is not necessary for the on-demand system.

Gasification boilers having several advantages. They can be used with several types of renewable biomass, such as wood, wood pellets, corn kernels or cobs, and switchgrass. This fuel can often be found inexpensively. Heat can also be stored in hot water tanks for later use.

Disadvantages include additional maintenance costs and labor costs for hauling and storing the biomass supply. The moisture content of the fuel plays a significant role in the efficiency of these units. The higher the moisture content, the less efficient the system will be because the excess moisture must be boiled off before heat can be generated. The biomass must also be stored appropriately, which could require creating a new space or shelter for the supply.

Because a gasification boiler costs significantly more than other systems and requires more commitment in terms of maintenance, labor, and fuel procurement, look for an inexpensive and local source of biomass with a relatively low moisture content.

A biomass gasification boiler will require an engineer to design the system to meet the load appropriately. In some instances, one boiler can operate all the greenhouses, but some greenhouses will require more than one system. It should be noted that the boiler will need to maintain a minimum burn rate to operate and that minimum burn rate may be higher than is necessary during the spring and fall to maintain optimum efficiency.

WASTE HEAT RECOVERY

When designing or improving your greenhouse operation it is important to consider any local opportunities that are available to utilize otherwise wasted energy. Many commercial or industrial processes generate waste heat in the form of hot water or flue gasses that are often just released back into the environment without being put to use. Coordinating with any neighbors to potentially harness these resources can reduce energy costs for the greenhouse and also reduce pollution because less fuel needs to be burned to heat the greenhouse space. For more information about recoverable heat systems, refer to the discussion of combined heat and power in the Biomass section of the Renewable Energy section of this guide.

MULTILAYER GLAZING

"Glazing" refers to the transparent material that is used to cover the walls and roof of a greenhouse, allowing light to still pass through and reach the plants. Polyethylene film is a common choice due to its low cost and easy customization to fit the greenhouse frame. Unfortunately, polyethylene film has a short lifespan of approximately four years. The R-value of a material measures how well that material resists heat flow, with the higher numbers being more insulating. The R-value of a single layer of polyethylene film has an R-value of around 0.85. A double layer of polyethylene plastic would have an R-value of approximately 1.5 and can create significant fuel savings in the winter months.

Polycarbonate is another material that is a popular glazing option. It is more durable that polyethylene and is also easily customizable. Single layer polycarbonate has an R-value similar to polyethylene, however there are options available for multilayer polycarbonate that have improved R-values. In this scenario, multiple sheets of polycarbonate are sandwiched together with air gaps in between. By doing this the R-value can often be boosted above 1.5 to as high as 2.5.

DYNAMIC TEMPERATURE CONTROL

Dynamic temperature control involves maximizing solar gain in the greenhouse during the afternoon and reducing ventilation to retain that heat into the early evening hours. The nighttime temperature set point is also reduced to a low level that is still tolerable to plants. The warmer afternoons and cooler evenings result in a daily mean temperature that remains unchanged. However, this approach provides an energy savings in the range of 10-50% depending on the crop and greenhouse location.

THERMAL ELECTRIC STORAGE

A thermal electric storage heater is a stand-alone unit that operates during off-peak times when electricity is cheaper to generate and store thermal energy for later use. The unit contains a high-density material that when heated is capable of storing large amounts of heat for extended periods of time. The electric heating element within the unit generates heat, the thermal material stores the heat and the unit later disperses the heat later when needed.

Refrigeration

Greenhouse operators often have refrigerated coolers and freezers to store their products. There are several no-cost and low-cost measures that can be implemented to keep refrigeration systems running efficiently:

- Make sure the door seals well, and replace any worn weather-stripping
- Install strip curtains on the door to minimize heat gain when the door is open
- Use LED lights in the cooler to reduce heat load associated with lighting
- Clean evaporator and condenser coils regularly
- Ensure that walk-in coolers have a minimum of R-25 insulation value in the walls and ceilings, and that walk-in freezers have a minimum insulation value of R-32 in the walls and ceilings and R-28 in the floor

Walk-in coolers and freezers typically run their evaporator fans constantly. Significant energy savings can be realized by installing evaporative fan controls. These controls either slow the fans or turn them off once the cooler reaches its set temperature.

Refrigeration compressors can often be replaced by more energy efficient compressors. Scroll compressors are some of the most energy efficient compressors available. The most efficient models are digitally controlled and have capacity modulation.

In colder climates, outside air economizers can be a good energy efficient option. They utilize outside air when the outside air is below the set temperature of the cold storage area, reducing the run time of the conventional refrigeration system.

Floating head pressure controls are an energy efficient option for larger refrigeration systems. They modulate the head pressure of the compressors to match ambient conditions, resulting in significant energy savings. Floating head pressure controls are typically most effective when used in conjunction with a control system that utilizes variable speed drive condenser fans.

Lighting

LED LIGHTING

Proper light levels are critical in a greenhouse due to the impact of lighting on crop growth, quality, and yield. For greenhouses using supplemental lighting, finding lighting with the proper light spectrum is critical. As with many other applications, LEDs offer an increasingly cost-effective alternative to the high-intensity discharge lighting commonly used in greenhouses. The Design Lights Consortium has recently created a policy for horticultural lighting, enabling greenhouses to see which products meet their standard for lighting efficacy and efficiency.

For more information, refer to https://www.designlights.org/workplan/horticultural-lighting/ and to the lighting section at the end of this guide.

ADAPTIVE LIGHTING CONTROL

Adaptive lighting controllers are relatively new to the US marketplace but have been used in Europe for over a decade. This technology consists of a central controller connected to light sensors attached to horticultural lighting fixtures in greenhouses. The controller is pre-programmed with daily light integral (DLI) data for the crop being produced. Based on real-time feedback from the lighting sensors (which determine incoming levels of sunlight), the controller sends a signal to the horticultural light fixtures to dynamically dim to provide the optimal level of light for the optimal time needed to maximize crop production. Numerous third-party studies indicate savings ranging from 30% to 60% of annual electricity used by greenhouse lighting systems, and an accompanying increase in crop yield.

Nursery

Open-air nurseries can benefit from many of the same technologies as greenhouses, except for the insulation and heating measures. Nurseries can also save both water and energy by managing their irrigation.

IRRIGATION

- Water only when necessary
- Test pumps every two years
- Move irrigation to off-peak hours to take advantage of lower electric rates
- Inspect wells to ensure there is no clogging or corrosion
- Add chlorine to irrigation lines monthly to kill bacteria and algae
- If running irrigation tapes or tubes on the surface, lift them periodically to keep debris from covering them and roots from pinching them
- Flush system regularly to remove blockages
- Regularly check for leaks, and fix all leaks immediately

DRIP IRRIGATION

Irrigation efficiency refers to the percentage of water removed from the water source that is utilized by the crop. Microirrigation is 90% efficient compared to sprinkler systems (10%). It is also more efficient than a flood system, as the water goes directly to the roots. A well-designed microirrigation system has almost no run-off or evaporation. It can be routed along the surface or buried in the soil. It can be used to deliver herbicides, fertilizers and insecticides. When designing such a system, take into account the land's contour when determining pressure and flow requirements, as well as the need for regular flushing of the system. Filters may be needed to ensure a minimum amount of damage from blockages.

PUMP UPGRADES

Testing irrigation pumps for pumping efficiency is a good way of

discovering if they are working at optimum efficiency, and can help determine if it is time to upgrade. Pump efficiency testing involves measuring gallons per minute, total dynamic head, and input horsepower. This information can then be used to determine if the pump is working efficiently. If the time is right for an upgrade, consider a NEMA premium efficiency motor.

VARIABLE SPEED DRIVES (VSDS) FOR PUMP MOTORS

A VSD is an electronic device that changes the frequency of the AC power going to a motor, varying the motor speed. When it is attached to a pump, the change in motor speed affects the flow and pressure of the water being pumped. VSDs are energy efficient because they regulate the flow of water to match demand, potentially eliminating the need for a flow control valve at the pump station. VSD installation is appropriate in some, but not all, irrigation operations. An irrigation engineer can determine whether or not a VSD makes sense for your irrigation system, as a number of factors such as piping, pumps, flow conditions over time, and operating hours are involved. Irrigation systems with dramatically varying flow rates tend to be good candidates.

Financial incentives are available for many motor controls. Visit **EnergizeCT.com** or call 877-WISE-USE to learn more.

SOIL MOISTURE SENSORS

Soil moisture sensors help conserve water by ensuring crops are watered only when necessary. There are three main types of sensors: tensiometers, gypsum blocks, and granular matrix sensors. The type of irrigation, soil, and crops on a farm will dictate which sensor will be most effective. Sensors should be placed near healthy crops with active root systems. There should be two sensors in the same location: a shallow one to read surface water levels, and another near the deeper roots. The average of the two readings will determine when to irrigate.

- ✔ Refrigeration: See Greenhouse Refrigeration section above
- ✔ Motors: Refer to motor section at the end of this guide.
- ✔ Lighting: Refer to lighting section at the end of this guide.
- ✔ Ventilation: Refer to ventilation section at the end of this guide.

Poultry (Turkeys & Broiler Chickens)

Poultry growers generally use a lot of energy, often second only to dairy. Like their counterparts in the dairy industry, there are ample opportunities for growers to reduce their energy use. Many times, upgrades can have a payback period of just a few years. An energy audit can help determine an estimated energy and cost savings based on your farm's particular situation.

CONTROLLERS

Today's poultry houses require constant managing of temperature in order to maximize bird growth. Thermostats can often drift out of calibration, allowing for over (or under) heating of the house. Water, feed, and air quality conditions must also be checked on a regular basis.

These can be overwhelming tasks if the farm is comprised of more than one or two poultry houses. Installing controllers in the poultry houses makes these tasks easier.

Poultry house controllers can coordinate heating, ventilation, cooling, and lighting systems so they work in an integrated fashion. The house environment remains constant, allowing the birds to realize their maximum potential. In addition, such precision controls can help reduce energy costs by eliminating over-heating and over-cooling. Controllers are also PC compatible, so regular reports on temperature, feed and water conditions, and even bird weights can be sent directly to the office computer. The data can then be analyzed for trends and trouble areas.

BROODING CURTAINS

Brooding curtains contain the chicks to a smaller portion of the house, allowing them to stay warm without the expense of heating the entire house. A tight seal is required to keep cool air from seeping into the brood chamber and chilling the chicks. To solve this problem, ensure that the brood curtain is sealing tightly. If using bird boards, set them back a foot or so into the non-brooding part of the house. This will create a tighter seal and lessen the likelihood of leaks. Install a heavy conduit or pipe in the bottom hem of the brood curtain for a tighter seal. Finally, make sure any holes in the brooding curtain are patched. Poultry producers may also find significant energy savings in installing an insulated brood curtain to reduce heat loss out of the brood chamber.

INSULATION

One of the first steps in lowering your heating costs should be to consider insulating your poultry house. If the house does not have solid side walls, consider enclosing it and adding insulation. Also, install or inspect your houses' vapor barriers for damage, as moisture reduces the insulation's effectiveness. Finally, check that the houses are well-sealed and seal any cracks with spray foam. An energy audit can help estimate the cost-effectiveness of installing new insulation or renovating from curtain sidewalls.

ATTIC INLETS

Ceiling (or attic) inlets are an effective way of keeping the flock warm during cooler months without increasing heating costs. They work similar to sidewall inlets, but are placed in the ceiling of the poultry house and draw heated air in from the attic.

Attic inlets can offer significant advantages in temperature and moisture control by pulling warm, dry air in from the attic rather than directly from the outside. The performance of attic inlets is highly dependent on the air sealing of the house. Static pressure control within a poultry house is necessary to ensure that attic inlets function properly.

CIRCULATION FANS

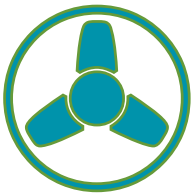
As air around the birds is warmed by the heaters it will tend to rise toward the ceiling. Circulation fans can significantly improve bird health and reduce heating costs by gently sending warm, dry air near the ceiling of a poultry house back down to the floor where it is needed. Proper care should be taken in the design of the fan system to ensure adequate circulation and avoid over-circulation which could cool the birds.

END WALL DOORS

End wall doors are usually used only twice per flock, but can be a costly drain on the wallet if they do not seal properly. Warped, old, or cracked doors can allow air leaks, which negatively affect the temperature within the poultry house. This can lead to higher heating costs, litter caking, lower feed intake, and smaller birds.

A good door should be strong enough to withstand weathering, provide a good seal to eliminate leaks, withstand the pressurization requirements of your house, and should have good insulating properties. High-quality, insulating end doors are available for both new and retrofitted houses and have been well-received by growers. These doors help to reduce

Types of Circulation Fans



There are many different types and sizes of circulation fans used in poultry houses. Most are basket fans, but box, paddle, and axial fans are also used to circulate air. Dropped ceiling houses can use 18" diameter 1/15 hp fans effectively. Open ceiling houses require larger fans due to exposed trusses and high ceilings.

temperature variations, which in turn helps to reduce the amount of propane used to heat the house. A door that is durable, insulated, and seals well is an excellent investment, and will help save on heating and repair costs down the road.

SOLID SIDE WALLS

Historically, curtain side walls were thought to be the most efficient means of regulating poultry house temperatures. However, it has been shown that solid walls help increase efficiency, both in regulating the birds' environment and the farmer's energy usage. Many producers are understandably cautious about giving up the safety factor of having curtains in the event of a power outage. This problem can be solved with a reliable, well-maintained generator set to automatically start in case of an outage.

Enclosing a poultry house can be expensive. When a farmer has multiple houses, the costs alone can make it seem as though the savings will not justify the expense. While it is recommended that all houses eventually be enclosed, there are temporary measures that will reduce fuel costs. Many producers begin by tacking the existing curtain in place and fitting foam or batting insulation over the former curtain opening. As funds become available the old curtain and new insulation can be sealed in with hard sheathing materials such as wood and metal.

Energy savings from installing solid sidewalls will vary depending on the type of house being renovated. Old 5-foot curtain sided houses might see a savings of up to 40%, while modern curtain sided houses with 24 inch openings, flaps, and insulation above and below the curtains may see a savings of around 15%. As always, fuel and energy savings are dependent upon a tight house. Ensure that as the insulation is being installed, the fit is tight and secure. Repair any breaks and tears immediately.

RADIANT HEATERS

Radiant heaters are fired with propane or natural gas and are used in agricultural, commercial, and industrial settings, such as poultry houses, aircraft hangars, and retail stores. Rather than heating the air in a room, radiant heaters work by transmitting heat directly to the floor, objects, and occupants of the heated space. This helps save heat from being wasted when warm air is circulated out of the building. There are different types of radiant heaters. They include radiant tubes, quads,

and circular heaters. Radiant tubes run lengthwise down the building or poultry house, and are generally 40 to 50 feet long. They are very efficient at emitting radiant heat over a large area. Quads and circular radiant heaters provide heat in a more localized fashion and more of these heaters are installed in a poultry house to provide uniform heating.

Unlike forced air heaters, which rely on convection of heated air to warm objects, no fans are required to deliver the heat to the floor. Heat is radiated quietly from the heater to the floor, and a reflector above the heater also helps direct the heat down towards the floor. Significant fuel savings are possible with radiant heaters as manufacturers typically recommend installing 15% fewer Btus of heating capacity for radiant heaters than forced air furnaces.

In poultry farms, one distinct advantage of radiant heating is that it does a better job of heating the litter pack. Since the heat is transferred directly to the floor of the house, this prevents the birds' body heat from being drained into the floor from their feet. The result is warmer birds and drier litter. Another advantage is that they can be mounted much higher in the house, so they do not need to be raised or lowered. They also heat the floor evenly, preventing the hot spots typically seen with pancake or radiant brooder heaters. The warmth spreads farther towards the side walls, meaning there is a larger comfort zone for the birds.

Some manufacturers also offer two-stage or dual-stage heating. The burner can be set at a higher or lower Btu output, depending on need. The higher setting is used only for times of severe cold. This will cut down on the amount of warm-up time and prevent temperature spikes, thus helping save fuel and extending equipment life.

Reflectors and radiant heaters should still be cleaned periodically to maintain optimum heating efficiency. Having an intense heat source near the ceiling can create a fire hazard if manufacturer's installation instructions are not followed explicitly. Be sure the ceiling is in good condition and check it frequently to ensure it is stable and not leaking insulation or other material onto the heater.

TUNNEL DOORS

Tunnel doors are built into the wall of the house and cover the evaporative cooling pads. They provide an easy and cost effective way to improve air flow and air mixing in the poultry house, and seal off the cold air coming

through the cool pads during the winter months. During the summer, they are highly effective at maximizing air flow and eliminating dead air spots. The doors open upward into the house, allowing the air to warm up enough first so it does not over-cool the birds. Manufacturers of tunnel inlet doors have taken steps to fix initial reliability and functionality issues. Most now offer metal hinges and frames instead of plastic ones. Doors have also been resized to more adequately fit into currently existing houses and many manufacturers have also increased R-values.

Tunnel doors remain a viable ventilation option, especially for houses in warmer climates where the right mix of air is critical. Be a wise consumer and compare the various options currently on the market. Make sure the hardware and equipment is of good quality. Proper installation is key with this technology, so ensure that a qualified individual with prior experience with tunnel doors is available.

TUNNEL VENTILATION FANS

Tunnel ventilation fans are exhaust fans located at one end of the poultry house. Two large air inlets, with doors or louvers, are installed at the opposite end. When running, the fans draw air through the openings, down the house and out the fans, producing a wind tunnel effect. This is an efficient method of cooling birds during the warmer months, and can be combined with evaporative cooling in extreme heat.

On many farms, tunnel fans are mistakenly turned off at night to take advantage of cooler outside temperatures and save energy. However, a flock of 25,000 four-pound chickens can give off up to 1 million Btus of heat per

Tips to Save Energy

To ensure maximum efficiency from your existing fans, keep them clean and well maintained. Dirty shutters can decrease airflow up to 40%. When cleaning the shutters, check the belts on belt-driven fans. Belt slippage reduces airflow and increases belt wear. Plan on replacing tunnel fan belts annually. Use cog-type fan belts, as they are typically 2% more efficient than v-belts.

hour. By turning off the fans, that heat remains in the house and overheats the birds. A few dollars might be saved initially by turning the fans off for the night, but poor feed conversion, lower bird weight, and increased bird mortality will reduce profits in the end. In order to keep profits and bird size high, it is recommended that producers choose the most energy efficient fans possible whenever installing or replacing old fans.

VENTILATION FANS - GENERAL

The easiest way to select fans is to choose those that have been run through standardized tests, such as the ones done by the Bioenvironmental and Structural Systems (BESS) Laboratory at the University of Illinois. BESS Lab tests fans with accessories such as shutters, guards, and cones to determine the efficiency of each one. The BESS Lab web site at **bess.illinois.edu** provides results from all of the fans tested.

POULTRY HOUSE LIGHTING

For poultry production, lighting is extremely important for stimulating birds to eat and drink to promote good health and growth. Significant advancement has been made in Light Emitting Diode (LED) lighting for poultry. One-to-one retrofit LEDs can save as much as 80% on lighting costs over incandescent bulbs. LEDs designed for poultry houses can last years in the harsh environment, allow for excellent dimming performance without sacrificing bulb life, facilitate easy wash-down with a hose, and produce light in specific spectrums that birds see. Poultry LEDs have come down in price significantly in recent years. Many LED lighting projects that not cost effective just a few years ago should be reevaluated now with updated pricing.

Egg Layers

Since egg houses are not typically heated, the most significant energy usage in the bird housing is for ventilation. Ventilation fans are run almost continuously in egg laying facilities. Ensuring you have the most energy efficient fans installed will provide you with the greatest energy saving opportunity.

Similar to broiler operations, lighting efficiency can be a cost-effective investment for egg layer farms. Though typically lights are used less for egg layers than they are for broilers, many of the same principles apply. In addition to high energy savings, LED lights designed for poultry can match desired light spectrums to best stimulate desired bird behavior, can last for years, and can be dimmed effectively. Compact fluorescent lighting offers similar energy savings to LEDs over incandescent lights though cost less to install at the expense of performance as compared to LEDs.

- ✔ Ventilation: Refer to the general ventilation section at the end of this guide.
- ✔ Refrigerated rooms: Refer to the refrigeration information in the greenhouse section.

Vegetables/Field Crops

In the production of field crops there are both direct and indirect energy inputs. These include the use of fuel and electricity to power field equipment and irrigation systems, and the embedded energetic cost of pesticides and fertilizers. In particular, nitrogen fertilizers have a high energetic cost, which NRCS estimates to be 20,000 Btu per pound on nitrogen. Also, growers can benefit from looking at motor use, or if the farm has any outbuildings or shops, savings may also be found in lighting.

- ✔ Irrigation: Refer to the irrigation information in the nursery section.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Soil Moisture Sensors: Refer to the section on soil moisture sensors in the nursery section.

DIESEL SAVINGS FOR TRACTORS

Tractors are an integral part of modern agriculture. They have allowed farms to increase exponentially in size and production. Unfortunately, they also consume vast amounts of diesel fuel. With volatility of diesel prices and increasing restrictions on diesel engine use, it becomes increasingly important to reduce the amount of fuel used while maintaining current production levels and schedules. Luckily, there are some easy-to-implement steps you can take to reduce the amount of diesel fuel used without sacrificing production or quality, like performing regular maintenance. Regular maintenance will help tractors perform more efficiently with less fuel. Consider integrating these fuel saving practices into a regular maintenance schedule:

- Replace air and fuel filters regularly.
- Check tire pressures frequently, and replace worn tires.
- Use proper ballast for each operation.
- Do not idle diesel engines for more than 10 minutes.
- Clean dirty fuel injectors.
- Keep ground-engaging tools sharp.
- Use the right tractor for the job (match horsepower up to load).
- Combine trips when possible, by modifying equipment if necessary.

CONSERVATION TILLAGE PRACTICES

Conservation tillage is a term encompassing various practices to reduce the amount of tillage used in a field. Tillage operations tend to be the most fuel intensive field operations, therefore reducing the number of tillage passes can significantly reduce fuel use per acre. Additionally, conservation tillage can reduce labor and maintenance costs, as well as improve soil quality and health. Consult with NRCS, University Extension, or other qualified agronomists in your area to determine a reduced tillage system that will work for you.

While conservation tillage will help preserve the soil and will save diesel fuel, the adjustment in these farming practices will likely require new equipment and may increase the use of herbicides.

REDUCING NITROGEN INPUTS

The cost of nitrogen fertilizer is tied to the price of petroleum and natural gas and can often be a significant cost for farms. One way to reduce the amount of nitrogen fertilizer used on the farm is to use natural nitrogen from either manure or "green manure" crops. Adding legumes, which are nitrogen-fixing, to a crop rotation can provide a nitrogen credit to the following crop and reduce the amount of nitrogen fertilizer needed. Consulting with an expert for nutrient recommendations is also a good idea to make sure application rates are appropriate and do not exceed crop needs. Soil testing is also recommended prior to fertilizer application.

REFRIGERATION

Many refrigeration systems can benefit from upgrades. Floating head pressure controls can significantly reduce energy use. Many systems have a fixed head pressure that is set to handle the worst conditions of

Tips to Save Energy

"GEAR UP AND THROTTLE DOWN" This is a fuel saving practice for high horsepower tractors pulling lighter loads. Fuel can often be saved by running an under loaded tractor in a higher gear and a lower engine speed. Be sure to stay within the engine RPM working range as specified in the operator's manual, and be careful not to overload the engine.

cooling in the summer. By allowing the head pressure to float, the energy needed to cool is reduced when the temperatures are lower than the maximum conditions. Economizers can sometimes be used in refrigeration systems. If the outside ambient temperature is lower than the refrigeration temperature set point, then filtered outside air can be used to cool the product.

Walk-in coolers and freezers use evaporator fans to distribute the cool air from the refrigeration system. These fans operate continuously. Fan controllers will reduce the speed of the evaporator fans, which causes less heat from the fan motor enter the space and also reduces the energy to the motor. Keeping the fan operating at this reduced speed keeps temperature stratification from happening in the cooler if the fan was turned off.

WATER HEATING

Heaters should be chosen based on how much hot water is needed over a specific period of time. When considering a new water heater, consider a model that is ENERGY STAR® rated to ensure the equipment operates at the highest possible efficiency. Typically this means choosing a unit with the highest energy factor (EF) rating for the fuel type used on the farm. 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. In your existing water heater, inspect the system and repair any leaks. Insulate the water heater and the lines from the tank.

Though most common on dairy operations, ideally any water heater near large compressors or similar equipment may benefit from waste-heat recovery to preheat water. Renewable energy such as solar water preheaters may also be applicable for farms with a large hot water demand. For farms with sparing hot water usage, instant hot water heaters provide good energy savings by heating water as needed, rather than storing large amounts of water at high temperature in a tank for extended periods of time. The EF rating of these systems can be over 0.95 though they may be limited by flow rate and high equipment and installation costs.

Orchards

Like farmers with field crops, orchard growers do not use as much energy as some other farm types. They can still benefit from reviewing their irrigation, motor, and diesel fuel use. If your orchard has any outbuildings or a retail space, savings can also be found in lighting. If your orchard stores product on-site using a refrigerated warehouse, there may be significant savings in the refrigeration.

- ✔ Irrigation: Refer to the irrigation information in the greenhouse section.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Diesel use: Refer to the diesel information in the vegetables/field crops section.
- ✔ Refrigeration: Refer to the refrigeration information in the vegetables/field crops section.

Vineyards

Vineyards can benefit from reviewing their refrigeration, lighting, motors, and diesel use. If your operation has any outbuildings or a retail space, savings can also be found in lighting.

- ✔ Irrigation: Refer to the irrigation information in the greenhouse section.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Diesel use: Refer to the diesel information in the vegetables/field crops section.
- ✔ Refrigeration: Refer to the refrigeration information in the vegetables/field crops section.
- ✔ Soil Moisture Sensors: Refer to the section on soil moisture sensors in the nursery section.

WINE TANK INSULATION

Wine cooling presents a major cost for any winery. Some estimate it can account for up to 50% of a winery's total electricity use. One of the best ways to cut back on energy use for refrigeration is tank insulation. Depending on the system chosen, an energy savings of up to 25% can be seen.There are two types of insulation appropriate for wine tanks: spray-on insulation and rigid foam panels. Spray-on insulation is good for large applications, but is not aesthetically pleasing. The rigid foam panels, which can be used either as a retrofit or on new tanks, are made from expanded polystyrene laminated to aluminum sheets. These foam panels also have a durable coating that can be white for external use or various colors for interior installations. The panels create a tight, easy-to-clean exterior that stabilizes interior temperatures.

Tips to Save Energy

When refrigeration equipment is insulated, it runs less, saving energy and money. Insulation also prevents mold growth and condensation on tanks, and eliminates ice formation. Refrigeration controls can also make your equipment more efficient and incentives are available to offset the cost. Visit EnergizeCT.com or call 877-WISE-USE to learn more.

Farm Breweries

Craft breweries are exploding in popularity and many farms are adding breweries on site to diversify their operations.

Brewing uses significant energy in the heating and cooling process for drying the malt, heating and boiling the mash, dissipating the heat generated in the fermentation process, refrigeration, and cleaning/sterilization. Data from the U.S. Environmental Protection Agency show that refrigeration, packaging and compressed air consume 70% of brewery electricity use, and the brewhouse uses about 45% of the natural gas/heating use.

Breweries use standard equipment such as pumps, motors and compressors. Choosing the most efficient model when purchasing and then performing regular maintenance on the equipment will ensure these systems are operating efficiently. Ensuring that your facility is operating with the most efficient lighting, water heating and refrigeration systems is also important for reducing energy consumption at your operation. More information on these technologies can be found in the Dairy section of this guide.

Some of the lowest-cost opportunities with a very quick payback include repairing steam and air leaks, changing air filters, converting lighting to LEDs, repairing insulation, cleaning exhaust fans and condenser coils, insulating refrigerant suction fans, maintaining good air flow around evaporators, and repairing damaged HVAC duct work. Projects with a longer payback include variable speed drives for motor controls, new insulation, high-efficiency HVAC, heat recovery, and programmable controllers. Breweries can often be good candidates for renewable heating and cooling, and solar hot water systems.

Get Tips from Energy Manual

The Brewers Association has developed an Energy Usage, GHG Reduction, Efficiency and Load Management Manual that contains more detailed information about energy-saving recommendations. Find this resource at www.brewersassociation.org/attachments/0001/1530/Sustainability_Energy_Manual.pdf.

Diversified Farms

Many Connecticut farms are small, diversified operations much like the kind found in generations past. It's not uncommon to find small operations that may have chickens, hogs, a few acres of crops, and perhaps a small greenhouse.

Often, these farms are intentionally designed for low production, with products sold at farmers markets. These operations have a very different energy use profile than their counterparts with larger operations. For instance, a small-scale poultry grower probably does not have the same chicken house set up as a commercial grower. The small diversified farm may have chickens in a coop rather than a poultry house, crops without irrigation, and a greenhouse that uses minimal temperature controls. This means these farms have lower energy use to begin with, simply because they are using energy for fewer things. Therefore, there are usually few energy efficiency opportunities on these farms beyond conservation activities. Still, farmers should read the sections on lighting, motors, and diesel use to see how they can reduce energy in those areas.

- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Diesel use: Refer to the diesel information in the vegetables/field crops section.
- ✔ Energy efficient stock waterers: refer to the stock waterer information in the dairy section.

Christmas Trees

Christmas tree farms generally do not use much energy compared to other farm types. However, Christmas tree growers should review their use of lighting, motors, irrigation, and diesel use as there may be savings opportunities in those areas.

- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Irrigation: Refer to the irrigation information in the greenhouse section.
- ✔ Diesel use: Refer to the diesel information in the vegetables/field crops section.

Equine

Since many equine operations have portable ventilation rather than permanent, lighting is the greatest energy efficiency opportunity on a horse farm. Please refer to the lighting section at the end of this guide for more information.

- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Radiant heating: Refer to the radiant heating information in the poultry section.
- ✔ Energy efficient stock waterers: Refer to the stock waterer information in the dairy section.

Maple Syrup

Maple syrup production is an energy intensive process. It takes approximately 40 gallons of sap to produce one gallon of syrup. The water has to be removed from the sap, and this is done conventionally by boiling the water from the sap.

REVERSE OSMOSIS

Reverse osmosis is a process used to concentrate the sugars in sap before boiling the sap. The sap is run through membranes that remove some of the water. This process significantly reduces the amount of water that needs to be evaporated, thus reducing fuel usage. The RO system also reduces the amount of time needed to boil the sap.

EVAPORATORS

Sap collected from maple trees is boiled in an evaporator pan to steam off the water leaving behind the concentrated sugars, thus making the syrup. Over the past few years there have been some significant advances in evaporator technology. The sap needs to be heated to boiling temperature, so the faster this can happen the less fuel is needed to evaporate the water. Evaporator pans are now being designed to utilize the heat being carried in the steam to preheat the sap, thus reducing the operating time of the heating system.

STEAM AWAY

A steam away is a device that uses the heat from the steam coming off the evaporator to preheat the sap before it enters the evaporator. There are also air injectors that add air to the sap, making it boil at a slightly lower temperature. The steam away reduces the temperature needed to bring the sap to boiling temperature.

BOILERS

Gas and oil fired boilers should be serviced annually to keep them in top working order. If the burner is more than 20 years old it is very likely switching to a newer model will be a cost effective improvement.

While energy and financial savings can be achieved by installing more efficient boilers the overall cost effectiveness of making an investment in new boiler technology needs to be evaluated carefully. When compared to all of the other energy saving options for syrup makers, installing a reverse osmosis system will provide the greatest reduction in boiling time and therefore cost reduction. The second most cost effective, energy saving investment is with the evaporators. If a syrup producer has invested in an RO system and a new evaporator, it makes the payback for replacing the boiler system much, much longer and possibly not worth it at all.

Honey

Honey production often involves small end-use equipment such as heaters and separating equipment. When equipment burns out it is recommended to purchase the most efficient replacements possible as most equipment has a quick payback. Honey processing facilities use many of the same types of equipment and lights found in other small-scale processing plants and are common on small diversified farms.

✔ Lighting: Refer to the lighting section at the end of this guide.

Goat Farms

Goat farms for meat or goat milk and goat cheese can benefit from many of the same energy efficiency measures as other types of agriculture, especially in areas such as lighting. Though typically smaller than Holstein dairy farms, goat milking farms can benefit from many of the same energy-efficient technologies for milk harvest, milk cooling, and water heating.

- ✔ Dairy: Refer to the dairy section for more information on milking equipment.
- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Diesel use: Refer to the diesel information in the vegetables/field crops section.

Farm Stores

Many farms now have stores where visitors can purchase items produced on site directly. The most common opportunities for energy-saving in farm stores is in lighting though depending on the selection of items available there may be opportunity to improve the energy efficiency of refrigeration systems or small motors. Installing high-efficacy lighting with occupancy sensors or upgrading to energy-efficient appliances can dramatically reduce running costs in farm stores.

- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Refrigeration: Refer to the greenhouse refrigeration section.

Cheese Processing

Cheese processing and similar facilities often find the most energy saving in lighting and a combination of motors or refrigeration systems. Often production facilities utilize high-bay lighting and may have significant opportunity to install new high-efficiency fluorescent lighting. As the technology develops, LED lighting has also shown promise for high-output and HID replacement applications. Periodically motors on processing equipment and exhaust fans may need to be replaced, in which case purchasing a premium efficiency motor or high-efficiency fan can quickly offset initial investment costs over conventional equipment. Facilities with cold-storage may also see significant savings in upgrading their refrigeration systems.

- ✔ Lighting: Refer to the lighting section at the end of this guide.
- ✔ Motors: Refer to the motor section at the end of this guide.
- ✔ Refrigeration: Refer to the greenhouse refrigeration section.

Motors

The National Electrical Manufacturers Association (NEMA) was created in 1926 to provide a means of standardization for electrical equipment. In 1991, NEMA created NEMA Premium® motors, a designation given to motors which exceed energy efficiency standards set forth by the US Department of Energy (DOE). This designation can only be given to manufacturers who belong to NEMA. Electric motors have a significant impact on total energy operating costs. Electric motors convert electrical energy into mechanical energy. Like all electromechanical equipment, motors consume "extra" energy in order to make the conversion.

WHAT MAKES A MOTOR EFFICIENT?

Efficiency is a measure of how much total energy a motor uses in relation to the rated power delivered to the shaft. NEMA Premium® electric motors have higher efficiencies, lower electrical power consumption and costs, and higher system reliability than standard motors. When installing a new motor or retrofitting existing motors to save money and energy, consider using a NEMA Premium® motor. While they may cost more initially, the payback is significant over their operating life in most applications, especially in areas where electricity prices are continually rising.

COST SAVINGS FOR ENERGY EFFICIENT MOTOR

The following is an example of the savings if an existing 50 hp motor were replaced with the same sized motor with the lowest energy efficiency requirements of the DOE compared with a motor with the highest energy efficiency - a NEMA Premium® motor. Assuming an

annual run time of at least 2,000 hours, the least energy efficient motor would save around $618 (at $0.10 / kWh) a year. In this example the lowest energy efficient motor costs approximately $1,450 and the most efficient motor costs $1,800. By investing another $350 to purchase a NEMA Premium® motor the savings would jump to $738 annually. This small additional investment would be repaid in less than three years. Here's the math: ($738 - $618 = $120 extra savings each year with the more efficient motor. Divide the extra cost of $350 ($1,800 - $1,450) by the additional savings to find the 2.9 year payback.)

OTHER BENEFITS

Premium efficiency motors are also usually made to higher manufacturing standards and stricter quality controls than regular efficiency motors. This can often mean the motor will last longer, with fewer maintenance costs and less downtime.

☞ **For more information on NEMA Premium® and a list of compliant electric motors, please visit:**
www.nema.org/Products/Pages/NEMA-Premium-Motors.aspx

Tips for Buying a New Motor

When purchasing a new motor, there are three important factors to consider:

1) If the motor will be running for extended lengths of time
2) How high the electric bill is in your local area
3) Selecting the right sized motor for your application

If the motor is only running sporadically, a retrofit to a NEMA Premium® motor or other motor will not make economic sense. However, the longer the motor runs, the greater the potential for savings and in new installations NEMA Premium® motors are the standard.

Energy Efficient Lighting

Lighting is one of the simplest, easiest, and most cost effective energy efficiency upgrades that can be made on the farm. Many farmers don't realize the impact energy efficient lighting can have on their energy costs, and are pleasantly surprised at the short payback period for many lighting projects. Nearly all farms use lighting in some form, and nearly all farms can benefit from increasing the energy efficiency of their lighting.

Through Energize Connecticut, Eversource and United Illuminating offer several programs to provide incentives to offset the costs of energy efficient lighting upgrades. Low or no-interest financing is also available to those that qualify. For more information, visit EnergizeCT.com or call 877-WISE-USE.

LED Lighting

Light Emitting Diode (LED) lights have advanced significantly in recent years. Over the past decade, LED lighting technology has rapidly advanced while prices have decreased by approximately 90%. LED lighting is quickly making other lighting types obsolete due to the sharp increase in efficiency and decrease in cost, using about 15% of the energy of an incandescent light. Except under rare circumstances, LED replacements have become available for any lighting scenario encountered.

The main advantages of LEDs are their efficiency (measured in lumens per Watt) and their long useful life, which reduces labor and material costs to maintain fixtures. LEDs last much longer than any other lighting option, with a useful life range of 40,000-50,000 hours and very little lumen loss over the course of their lifetime.

Standard replacements for common incandescent lights are already widespread. For example, a 100-watt incandescent bulb may be replaced by a 12-watt LED. LEDs also dim lower and more smoothly than other types of lighting and do not experience shortened lifetimes from dimming, though the dimmer switch will need to be replaced with one designed for LEDs. LEDs are largely available as one-to-one screw-in retrofits for small standard incandescent bulbs.

Tips for Choosing LED Lighting

- Choose lights designed for agricultural applications if possible
- Choose lights that come with a three-year warranty or better
- Consult third-party listings, like the Design Lights Consortium, to evaluated LED options (designlights.org)
- Consider installing timers or photocells to outdoor lighting
- Consider the use of motion/occupancy sensors where appropriate
- Keep reflector shields and lenses clean
- If you have a requirement for certain lighting levels on your farm, check with an electrician to ensure adequate lighting levels are met. The American Society of Agricultural and Biological Engineers (ASABE) publishes a lighting standard with recommended illumination levels in Agricultural Facilities- ASAE EP344.3 "Lighting Systems for Agricultural Facilities.

Linear fluorescent and HID replacement LED fixtures are also becoming available. There are known safety issues with retrofitting existing linear fluorescent and HID fixtures with LED bulbs since LEDs are largely not compatible with the ballasts required for fluorescent and HID bulbs. Therefore, it is important to work with an electrician when installing high-wattage LEDs and replace the entire fixture when replacing high-output lights.

Legacy Efficient Lighting

Traditional 1 ½ inch T-12 fluorescents have been in use since the 1930s. Many people had previously switched to more efficient T5 and T8 fluorescent lighting, which offered less noise, more light per watt, better color rendering, no flickering, cooler operation, and electric cost savings. However, today's LEDs can offer the same benefits with even lower energy consumption. LED replacements are readily available either through retrofit kits to convert exiting fixtures or by replacing the entire fixture with an LED-based model.

When originally introduced, compact fluorescent lamps (CFLs) were an efficient alternative to incandescent bulbs, using about 1/3 the electricity of an incandescent. Cold cathode fluorescent lamps (CCFLs) are an improvement on CFLs, with better dimming and longer life. However, in recent years LEDs have trumped CFLs and CCFLs in both energy efficiency and cost-effectiveness, and most operations currently using CFLs or CCFLs should consider transitioning to LEDs.

High Intensity Discharge (HID) lighting encompasses mercury vapor, metal halide, pulse-start metal halide, and high-pressure sodium lighting with wattages ranging from 150-400 watts. They are typically used in areas requiring a high lighting output, such as yard lights, freestall lighting for dairy farms, and greenhouse supplemental lighting. LEDs can now be installed in these areas to provide the same quality of lighting and longer lifespan at a fraction of the energy consumption

General Ventilation

Most farms use fans to cool livestock and workers as well as circulate fresh air into enclosed spaces. The efficiency of circulation fans used is rated in terms of pounds of thrust per kW of energy required by the fan motor (lb/kW). Exhaust fans are generally used to expel heat and foul air from buildings. These fans create a difference in static pressure inside and outside of the building. Exhaust fan efficiency is rated in terms of the cubic feet of air moved per minute (CFM) per watt of energy required (CFM/Watt) and is often dependent on this static pressure change.

Farm-duty ventilation fans can be expensive to replace but worth the extra money to buy an efficient fan. Whenever buying new fans, EnSave recommends buying the most energy efficient fans available. The energy savings from an efficient fan will quickly offset any initial savings realized by purchasing a less expensive and less efficient fan. The fans generally recommended represent the midpoint between the minimum efficiency threshold and the highest efficiency fan as grouped and tested by Bioenvironmental and Structural Systems (BESS) Laboratory.

General measures to increase ventilation energy efficiency include:

- Establish a periodic fan cleaning schedule (every 3 to 4 weeks). Tests performed by the University of Georgia showed that dirty fan housings, shutters, and blades can reduce air flow and efficiency by up to 27%. Air flow also directly affects humidity levels, flock health, and performance.
- Inspect and replace worn belts and pulleys. Tests performed by the University of Georgia showed a 10-30% drop in fan output, mainly from worn belts.
- Stage the tunnel fans so that the newer, more energy efficient fans are the first to turn on if all of the fans are not needed.
- Install fan covers over unused fans during the heating season.
- Straighten bent cones and repair shutters that are not closing properly.

Renewable Energy Opportunities

COURTESY OF THE CONNECTICUT FARM ENERGY PROGRAM

Using renewable energy can reduce your energy costs because you are offsetting some of what you would pay for electricity, diesel, propane, or natural gas with energy you generate yourself. Renewable energy also has less of an environmental impact than energy generated by burning fossil fuels. Because of its benefits, many states are encouraging residents to implement renewable energy projects. Connecticut has several opportunities for long-term contracts, financing, and grants for renewable energy. Connecticut's renewable portfolio standard requires 27.5% of the electricity sold in the state to be from renewable sources, and this requirement will increase to 48% by 2030.

Renewable energy can have high upfront costs, but save energy costs over the life of the project. Before you investigate renewable energy, make sure you have made your operation as efficient as possible and done all you can to conserve the energy you already use. It doesn't make much sense to invest in a solar panel or wind turbine to power a barn that is full of air leaks and has outdated fans and lights. The information below will help give you a sense of some renewable energy opportunities for your farm. We have included links to some other sources of information, should you wish to investigate this further.

Net Metering

Net Metering is a method of measuring the energy consumed and produced by a customer's generating facility. Net Metering allows a customer to reduce the amount of energy purchased from an energy supplier and to provide a value for the excess energy (exported energy to the Grid) produced by their generator. A new form of "tariff" compensation is under development as of the publication of this guide and is scheduled to replace net metering in its current form in the 2021-2022 timeframe.

☞ **For more information, visit www.ct.gov/deep/cwp/view.asp?a=2715&q=558644&deepNav_GID=1626**

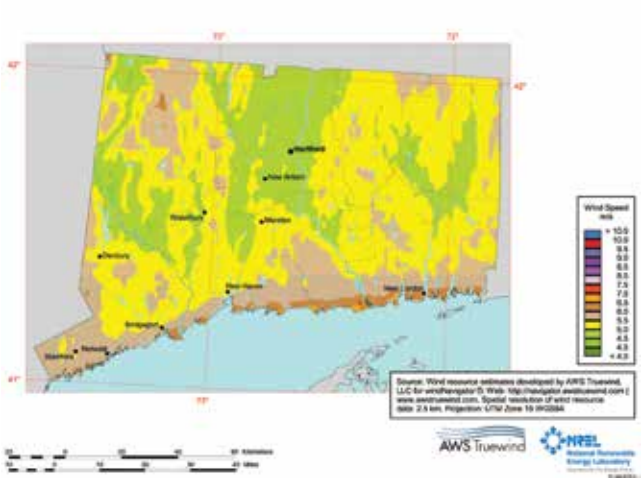
WHAT IS VIRTUAL NET METERING?

Virtual net metering allows customers who operate behind-the-meter generation (Customer Host) to assign surplus production from their generator to other metered accounts, (Beneficial Accounts) that are not physically connected to the Customer Host's generator. Agricultural customers are eligible to apply. Visit http://energizect.com/government-municipalities/programs/virtual-net-metering to learn more.

Wind Energy

Wind turbines convert the kinetic energy from wind into mechanical power that runs a generator. You may have driven by a wind farm with acres of large wind turbines providing power to the electric grid. The same technology can be used on a smaller scale to generate electricity for your farm. Small wind turbines are available for farmers who wish to offset some or all of their power use.

Connecticut Annual Average Wind Speed at 80m



☞ **More information about wind energy can be found from the American Wind Energy Association: www.awea.org/wind-101**

☞ **The U.S. Department of Energy also has a good resource about small wind: https://windexchange.energy.gov/small-wind-guidebook#parts**

The map on page 53, from the U.S. Department of Energy, shows mean annual wind speeds at an 80 meter height. Areas with an average annual wind speed of at least 6.5 meters/second are considered to have suitable resources for wind development.

While this map primarily considers commercial-scale wind development, the map gives you a sense of the areas in Connecticut that have the best potential for wind. In this case, the areas shaded in brown and yellow have greater potential than the green areas. However, wind activity can vary substantially on the micro level, so you should get a professional evaluation of your wind energy potential if you are seriously considering installing a turbine. A professional can install an anemometer to measure wind speed and determine whether your location is a cost-effective location for a wind turbine.

INCENTIVES FOR WIND PROJECTS

The Connecticut Green Bank provides innovative financing products in partnership with a variety of financial institutions. Connecticut also offers competitive procurement opportunities which allow bids to be submitted to utilities for consideration of a 15-year contract. These programs are referred to as the zero emission renewable energy contract (ZREC) and low emission renewable energy contract (LREC) and are scheduled to remain in the market until roughly 2021 at which point the utilities will administer successor programs.

☞ **More information about Connecticut Green Bank and other opportunities is available at www.ctgreenbank.com**

☞ **Information on the ZREC/LREC program can be found at www.ct.gov/deep/cwp/view.asp?Q=553942**

Solar Energy

Every hour, more energy from sunlight strikes the earth than the entire human population uses in a whole year. The sun's heat and light provide an abundant source of energy that can be harnessed in many ways. There are a variety of technologies that have been developed to take advantage of solar energy. These include concentrating solar power systems, passive solar heating, daylighting, photovoltaic systems to generate electricity, solar hot water, and solar process heat and space heating and cooling.

SOLAR PHOTOVOLTAIC (PV) CELLS

PV cells are the technology used to convert solar energy into electrical power. Packaged together, PV cells are called an array. A solar array can be installed in many places, although the efficiency of the system is affected by climate conditions. Most modern PV cells are about 15% efficient in converting sunlight. Your solar system can either be off-grid, meaning the array generates only for your home and is not tied to the electric grid, or it can be tied to the grid, meaning you can sell excess power back to your electric company. With the increase in utility demand for clean energy sources, many people find a grid-tied system to be beneficial. Still, a solar PV system can be costly, so investigate the payback period and financing and ownership options, and make sure you are saving energy in other ways before investing in a PV system.

☞ The Connecticut Green Bank administers a residential solar program and maintains an unbiased information platform on Connecticut's solar market. Visit www.gosolarct.com for more information.

SOLAR HOT WATER

A solar water heater can be a cost effective way to provide hot water for your farm. The solar water heater has two components, a storage tank and a solar collector. An active system has circulating pumps and controls, while a passive system does not. There are several sub-categories of solar heating systems within the passive and active designation. Solar hot water can cut water heating expenses by 50-80%. However, before committing to a solar water heater you should first check with a reputable installer to make sure the system makes sense for you farm's needs, and that you are comfortable with the payback period.

☞ The U.S. Department of Energy's Energy Efficiency and Renewable Energy has a good resource about solar water heating: http://energy.gov/energysaver/articles/solar-water-heaters

PASSIVE SOLAR

A farm can make good use of "passive" solar design, by maximizing the sun's heat and light instead of using mechanical systems. These systems are generally fairly simple and low-cost, so they can be a good choice for the farm. A good example is a solar (also called energy-free) stock waterer, which uses the sun's energy rather than electricity to heat livestock drinking water. Farms can also include renovating a building to add a skylight or south-facing windows to maximize light and heat, especially if the farm is planning a renovation anyway. To reduce the sun's heat, strategically placed awnings and landscaping should be considered. A solar greenhouse can be a good option for a small grower to extend the growing season without relying on fuels to heat the space.

☞ The National Sustainable Agriculture Information Service has a free online publication for those interested in learning more about a solar greenhouse: www.attra.ncat.org/viewhtml/?id=59

Geothermal and Heat Pumps

Geothermal energy converts the heat from just below the earth's surface into a usable energy source. On a home or farm, the most common geothermal technology is using a geothermal heat pump to heat or cool spaces. Unlike wind or solar, which are largely dependent on temperature and climate, the temperature a few feet below the earth's surface (below the frost line) is relatively constant despite major fluctuations in the air temperature.

A geothermal heat pump (also known as a ground-source heat pump) uses the earth as a heat source in cold weather by drawing heat from the earth. In warm weather, the pump rejects heat back into the earth in order to provide cooling. This type of heat pump is anywhere from 25-50% more efficient than an air source heat pump, because the earth's temperature is much more constant than outside air temperatures. Typical payback periods for the additional incremental cost over an air-source heat pump is approximately 5 to 10 years.

A heat pump must have a heat exchanger installed in contact with the ground or ground water, in order to extract or dissipate heat. Ground loops in which the heat pump operates to circulate a fluid, collecting and rejecting heat, in order to heat or cool a building. This most popular adaptation of this technology often utilized in CT involves a 6" borehole 400' to 500' in depth. These ground loops can often have a 50-year warranty, although some are expected to last up to 100 years. According to the U.S. Department of Energy, geothermal heat pumps can save between 25-50% of heating and cooling costs compared to air source heat pump systems. The efficiency of a geothermal system varies on the climate, with the highest efficiency achieved on cold winter nights.

The Connecticut Energy Efficiency Fund (administered by Eversource and Avangrid) provides a rebate for heat pump technologies, which can provide significant savings compared with conventional heating technologies like oil and baseboard electric. See www.energizect.com/your-home/solutions-list/geothermal-heat-pump-rebates for more information. See www.ctenergyinfo.com/energy-programs.htm for more information about the CEEF programs.

☞ **The CT Green Bank has financing available for heat pump technologies through C-PACE for commercial projects and**

SMART-E for residential projects. Please visit https://ctgreenbank.com/programs for more information.

There are other ways to use geothermal energy besides heat pumps, although most others are used in large-scale commercial applications or to generate electricity for power plants. Some greenhouses have installed direct-use geothermal applications although most of these have been large greenhouses in the Western U.S., which is a better fit for direct-use geothermal. Connecticut has no economically-feasible sources for these direct geothermal energy systems.

Biomass Technologies

Biomass is a term used for any type of renewable, non-fossil fuel that comes from organic matter. Common biomass types include wood, paper, yard clippings, agricultural residues, switch grass, and animal waste. Often, biomass uses organic waste material which has to be disposed of anyway and turns it into usable energy. Biofuel is biomass that has been converted to liquid or gas. Biomass is often used to generate electricity, heat or biofuels. Ethanol and biodiesel are the most common biofuels in use throughout the U.S.

The availability of biomass resources depends on your location and particular fuel needs. North central and southwestern Connecticut are identified as having very good solid biomass resources according to the National Renewable Energy Laboratory (NREL). Choosing a local source of biomass (typically ~50 miles away) is important because due to the lower energy density of the fuel, transportation costs can quickly outweigh potential environmental and cost benefits.

The primary way most biomass resources are utilized is via combustion to generate heat, captured as hot air, hot water or steam. This thermal energy can be used for space or process heating depending on the particular needs of an enterprise.

Best practices include drying the feedstock to some degree before combustion. This is because any moisture remaining in the biomass will need to be "boiled off" and vaporized, thus reducing the amount of recoverable energy available. Additionally, consideration needs to be given to properly sizing the biomass feedstock. This ensures continuous and smooth operation with the feedstock handling system, preventing any downtime.

Biomass can also be used to fuel combined heat and power (CHP) systems that generate electricity and also recover waste heat for secondary heating purposes, for instance water heating. This heat, normally wasted in conventional power generation systems, can be recovered as useful energy. The total efficiency of such systems often reaches 60-80% due to this additional utilization of thermal energy. Any facilities that have a thermal load large enough to utilize the excess heat may benefit from integrating a CHP system to their operation. Farms without the need for the excess thermal or electrical energy may have the opportunity to work with neighbors or other local industries to share

the produced energy, as well as generation costs to make a CHP system technically viable and economical.

The most familiar example is a methane digester (a type of anaerobic digester) which solves the manure-disposal issue on dairy farms while also generating an income for the farmer. As of summer 2019, the Environmental Protection Agency reports there are two methane digesters on Connecticut dairies. There are several firms that specialize in conducting feasibility studies for anaerobic digesters. A feasibility study is essential considering a digester can be a multi-million dollar investment, and digesters are not appropriate for all farms.

☞ **The U.S. Environmental Protection Agency's AgStar program promotes methane digesters, and has a variety of resources, conferences, and publications: www.epa.gov/agstar**

On a smaller scale, many farms, homes, and businesses have found biomass heating (using a corn or wood pellet-fired stove) to be an economical alternative to fossil fuels like propane. Farmers have the option of also growing and marketing their own biomass heating products as a supplement to other agricultural production. As an example of this, the Hudson Valley Grass Energy project in New York takes leftover hay and converts it to pellet fuel: **http://hvgenergy.wordpress.com**

☞ **This article from the Union of Concerned Scientists presents more information about types of biomass used on the farm: www.ucsusa.org/clean_energy/technology_and_impacts/impacts/growing-energy-on-the-farm.html**

☞ **The State of Connecticut is supporting heat pump technology as a way to reach its climate goals. Find rebates on heat pumps at www.energizect.com/your-home/solutions-list/high-efficiencyheating-cooling**

☞ **The U.S. Environmental Protection Agency has a resource for qualified biomass/wood pellet heaters that are cleaner burning than the alternatives: www.epa.gov/burnwise/owhhlist.html**

Compost Aeration and Heat Recovery (CAHR)

CAHR systems are being explored as an alternative to large anerobic digesters for use on smaller dairy operations. Heat recovered from the manure compost can be used for water preheating on the farm, while compost generated can be sold as a value-added product for the business.

The CAHR process begins when composting materials are loaded on to perforated pipes in an aeration bay. Fresh air containing oxygen is drawn through the compost into the pipes using a blower fan. The air, preheated by the compost, is run through a specialized heat exchanger to transfer heat to a circulating fluid. The air can then be exhausted outdoors, while the heated fluid can then be pumped to points of heating demand around the farm.

The increased compost aeration accelerates the timeframe for having compost available for market. A pilot program running on a farm in Connecticut has seen a previous two-year time to market for compost cut down to as little as three to six months using the new CAHR system.

The farm has also benefited from reduced fuel and labor requirements using the new operating procedures (1,400 gallons of diesel saved and 400 labor hours reduction). Heating oil consumption for water heating has also been reduced by 760 gallons over the 12-month time period considered. Between the accelerated compost sales ($21,600), diesel and labor savings ($20,000) and reduced heating oil consumption ($2,280) the farm has experienced a net benefit of $43,880 so far.

CT Farm Energy Program installed the 1st Compost Heat Recovery System in CT at Collins Powder Hill Farm located in Enfield, CT. This project was made possible by support from CT Department of Energy and Environmental Protection (DEEP) and the US Department of Energy (DOE). CT Farm Energy Program has been working in conjunction with the Collins Family who own and operate Collins Compost along with Agrilab Technologies who designed, installed and monitored the system during the first year of the pilot project period. Visit https://ctfarmenergy.org/ to learn more.

Biofuels

Biofuels are created by converting biomass into liquid fuels that are used for transportation or machinery. In many cases, biofuels help to lower harmful pollutants and burn similar or better than conventional fuels. Using biofuels reduces emissions because the CO2 released during combustion is offset by the CO2 absorbed when the biomass feedstock is growing.

Biodiesel or biodiesel/diesel blends have become popular as alternatives to pure diesel fuel. Although the energy content of biodiesel can be slightly lower, it has the added benefits of a higher cetane number (reducing engine knocking), increasing the lubricity of the fuel (preventing premature wear on the engine), and reduced emission of incomplete combustion products in the exhaust gasses (lower particulate matter and pollutants).

Before using or blending biofuels into your existing fuel source be sure to consult with your engine's original equipment manufacturer (OEM) recommendations to determine what ratio is optimal for your engine.

Funding Sources

There are several resources for a farmer interested in accessing assistance and/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 Connecticut farms for such assistance. It is best to check with these agencies and programs directly as funding availability and program offerings are subject to change.

RURAL ENERGY FOR AMERICA PROGRAM (REAP)

REAP is a federal program through USDA Rural Development. To foster rural economic development and growth, Congress passed the Rural Energy for America Program (REAP) known as Section 9007 of the 2008 Farm Bill. Rural small businesses and agricultural producers can apply for grants, (25% of total eligible costs) guaranteed loans (75% of total eligible costs) and combination grant and guaranteed loan (75% of total eligible costs) for financing renewable energy projects and energy efficiency improvements.

Eligible renewable energy projects include projects that produce energy from: wind, biomass, anaerobic digester, ocean, solar, geothermal, hydrogen and hydroelectric. The renewable energy project can produce any form of energy, including heat, electricity, or fuel. The minimum project size for a renewable energy project is $10,000. Eligible energy efficiency improvement projects include improvements to a facility, building, or process that reduces energy consumption, such as retrofitting, lighting, or insulation, or purchasing or replacing equipment and motors with more efficient units. Energy efficiency projects must replace something that already exists. The minimum project size for an energy efficiency project is $6,000.

Projects cannot involve residential use. Project purchases incurred prior to submitting an application are not eligible. For all projects: the system must be technically feasible, must meet environmental requirements and must be owned by the applicant. If you do not qualify as an agricultural producer but as a rural small business, you must be located in a rural area. Each year, a NOSA is posted to solicit applications, and awards are made several months after the deadline. **For more information about REAP, visit Rural Development's Connecticut web page at www.rd.usda.gov/ct**

CONNECTICUT FARM ENERGY PROGRAM

The Connecticut Farm Energy Program (CFEP) is a program of Connecticut Resource Conservation & Development Area, Inc., with support from USDA Rural Development and the Connecticut Department of Energy and Environmental Protection. The Connecticut Farm Energy Program serves as a resource for energy and agriculture as it relates to agricultural producers and agricultural-based small business in Connecticut while also providing REAP grant writing assistance to eligible agricultural producers and agricultural based small businesses located in Connecticut. To date CFEP has helped farms and rural small businesses secure over $4 million in USDA Rural Development REAP grants and loans which equates to over $16 million dollars in energy efficient and renewable energy projects installed in Connecticut since 2010.Visit their web page at **www.CTFarmEnergy.org** or **www.facebook.com/ctfarmenergy**

ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP) AGRICULTURAL ENERGY MANAGEMENT PLANS

This program through the USDA Natural Resources Conservation Service (NRCS) provides financial assistance for agricultural energy management plans (AgEMPs). The main component of these plans is a farm energy audit. AgEMPs can be used as audits to support REAP applications, and the financial assistance offered by the state means producers pay less than market rate for these plans. AgEMPs are provided by certified technical service providers, private contractors who are specialists in the field. To learn more about the AgEMPs, visit **www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?&cid=stelprdb1046252** or contact the USDA service center near you.

ENSAVE, INC.

EnSave, Inc. provides farm energy audits for REAP and AgEMPs, and can help connect farmers with incentive opportunities that may be available. More information can be found at: **www.ensave.com**

ENVIRONMENTAL QUALITY INCENTIVES PROGRAM (EQIP) PROGRAMS BENEFITING ATMOSPHERIC RESOURCES

Connecticut NRCS offers cost-share for practices that benefit atmospheric resources. The program covers:

- Practices to minimize or reduce emissions of fine particulate matter, odors, and/or greenhouse gases
- Energy conservation and energy efficiency practices
- Odor control, reduction of methane emissions

Many of the equipment and practices mentioned in this guide may be eligible under this program. For more information, visit **https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/** or contact the USDA service center nearest you.

CONNECTICUT DEPARTMENT OF AGRICULTURE VIABILITY GRANTS PROGRAM—FARM TRANSITION GRANT

This matching grant offers up to $49,999 for projects. The intent of the grant is to enable the farm to expand, diversify or transition the farm into a new market. The purchase of plants or animals, among other expenses, are unallowable. Energy efficiency upgrades are an eligible category so long as the project also meets the intent of the grant. A 50% cash match is required. Applications are due annually in February. More information can be found at **www.CTGrown.gov**

CONNECTICUT GREEN BANK

Connecticut Green Bank was established by Connecticut's General Assembly on July 1, 2011 as a part of Public Act 11-80, at the time under the name Clean Energy Finance and Investment Authority. This new quasi-public agency supersedes the former Connecticut Clean Energy Fund.

The Green Bank's mission is to make clean energy financing accessible and affordable for Connecticut homeowners, businesses and institutions. As the nation's first full scale clean energy finance authority, the Green Bank leverages public funds to drive private investment and scale-up clean energy deployment in Connecticut. For more information, visit: **www.ctgreenbank.com**

ENERGIZE CONNECTICUT

Energize Connecticut is a statewide initiative administered by Eversource, United Illuminating, Southern Connecticut Gas, and Connecticut Natural Gas. This initiative supports various energy efficiency programs that provide financial incentives and financing to help Connecticut consumers reduce the energy used in their homes and businesses. Programs offered under this initiative are paid for by a charge on customer energy bills. **www.EnergizeCT.com**

LOW AND ZERO EMISSION RENEWABLE ENERGY CREDITS (LREC AND ZREC)

Eversource and UI will accept bids from renewable energy project developers/owners on the energy their system will produce. This LREC/ZREC program creates a market-driven bidding process for projects to compete to obtain a 15-year revenue stream from the sale of RECs to the electric utilities. More information can be found at Eversource and UI's websites. Low Emission Renewable Energy Credits (LREC) and Zero Emission REC (ZREC) –Most farms fall under the 'small projects' category launched by the utility companies in 2013. Farms will get a set amount of credits based on the energy produced over a period of fifteen years. Contact: lrec.zrec@eversource.com or lrec.zrec@uinet.com

NORTHEAST SARE (Sustainable Agriculture Research & Education)

The SARE program offers a variety of grants, including grants to farmers who implement an innovative idea in sustainable agriculture. They also have a database of past projects where farmers can learn about projects other farmers have tried. Northeast SARE covers Connecticut, and is administered through the University of Vermont. **www.northeastsare.org**

ENERGY STAR©

The Energy Star program is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. Energy Star helps consumers by labeling energy efficient products, and offers rebates and tax credits for qualifying energy efficient equipment. Energy Star offers a directory of EnergyStar rebates and special offers searchable by zip code at **www.energystar.gov/index.cfm?fuseaction=rebate.rebate_locator** Information on tax credits can be found at: **www.energystar.gov/index.cfm?c=tax_credits.tx_index**

DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY

The DSIRE database allows users to find information about

several publicly-run energy efficiency or renewable energy incentives, and is searchable by state. **www.dsireusa.org**

FINANCING OPTIONS

REAP Loan: please refer to the REAP information on page 59.

C-PACE: Commercial Property Assessed Clean Energy (C-PACE) is an innovative program, administered by the Connecticut Green Bank, that is helping commercial, industrial, and multi-family property owners access affordable, long-term financing for smart energy upgrades to their buildings. C-PACE allows building owners to finance qualifying energy efficiency and clean energy improvements through placing a voluntary assessment on their property tax bill.

Property owners pay for the improvements over time through this additional charge on their property and the repayment obligation transfers automatically to the next owner if the property is sold. Similar to a sewer tax assessment, capital provided under the C-PACE program is secured by a lien on the property, so low-interest capital can be raised from the private sector with no government financing required. For more information, visit **www.cpace.com**

FSA: The Farm Service Agency is responsible for the administration and delivery of disaster assistance, USDA commodity programs, and low interest loans as a lender of first opportunity. In 2018, CT FSA provided $4.26 million in loans and $2.06 million in program assistance to CT producers. These programs are designed to help ensure the long term viability of Connecticut agriculture. In addition to those programs, producers can record acreage and crop diversity for their insurance purposes through the agency at one of the five offices across the state.

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additional l y, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint filing cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:

MAIL: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410

FAX: (202) 690-7442; or

EMAIL: program.intake@usda. gov

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1066 Saybrook Road, PO Box 70
Haddam, Connecticut 06438
860-345-3977
www.CTFarmEnergy.org