



OVERVIEW

Livestock operations include confined animal operations (dairy, swine and poultry, among others) and other less intensive farms. Energy consumption by livestock operations is relatively low compared to other types of operations and accounts for approximately 8% of agricultural direct energy use in the United States (1) (2).

Specific energy consuming applications in livestock production include ventilation systems, refrigeration, lighting, heating, watering, motors and waste handling. The energy used to produce the feed inputs to livestock production may be significant, but this energy use usually occurs outside of the livestock operation and is not directly relevant to reducing energy consumption in livestock operations.

Despite the relatively low energy requirements, livestock operations offer unique opportunities for energy efficiency and conservation on New Jersey farms. This publication will explore various ways in which energy use around the operation can be optimized by the livestock producer. NRCS and the University of Wisconsin have developed an online energy self-assessment tool that complements the material in this fact sheet (3).

ANIMAL HOUSING VENTILATION

Different types of livestock shelters have specific ventilation requirements. Proper design and regular maintenance of ventilation systems are essential for optimizing energy efficiency. To provide efficient movement of air through the structure fans should be properly sized and located and should be as efficient as possible. To select the most efficient fans, compare the ratio of cubic feet per minute to the motor wattage at the same static pressure.

The most energy efficient method of moving air is natural ventilation. Often structures can be designed to make maximum use of natural convection and wind currents in providing ventilation. In planning new walled structures, incorporate louvers and large doorways into the design. Linkages used for opening vents must be lubricated regularly. In structures with fewer than four walls, orient open sides to allow a laminar flow of air through some part of the structure. Roof vents can also help in reducing ventilation-related energy expenditures, especially where wall venting alone results in unacceptably high temperatures.

Keep fans clean and properly lubricated. Where possible, the use of NEMA Totally Enclosed Fan-Cooled or

Wet-Location motors can reduce losses caused by the corrosive action of water and nitrogen compounds present in livestock shelters and similar facilities. Keeping a few pedestal fans around the farm can also be of great value. These fans can be moved to specific locations that need spot ventilation or cooling instead of operating the entire structure's ventilation systems.

Install fans and passive ventilation devices so that they are away from obstructions. Design fans, inlets and the structure itself to minimize airflow resistance and provide uniform flow. In most applications an undisturbed, laminar flow of air through the structure is ideal.



Livestock Structure Ventilation Devices

PHOTO: PENNSYLVANIA STATE UNIVERSITY

LIGHTING

Energy used to light livestock operations can be optimized by installing lighting fixtures properly and using appropriate lamps. Using wall-mounted lighting fixtures where possible can increase energy by reducing airflow resistance within the structure, reducing ventilation-related energy use. Using high-pressure sodium lamps also helps, since these lamps are more efficient than other types (70 percent and 40 percent less energy than incandescent and fluorescent lights, respectively) and produce a light spectrum well-suited to livestock operations. Installation of photocells, timers or other controls ensures that lighting systems operate only when needed. Using multiple switches to divide lighting fixtures into zones allows lights to be turned off in unused portions of the structure.

INFRARED HEATING

Infrared heaters are often a useful method of delivering heat where it is needed and can be a good solution for farrowing, nursery and similar areas. Good thermostatic controls for infrared heating devices help minimize energy use. Install these controls in the area intended to be heated by infrared devices. Sensors should be of a color similar to that of the floor or the animals being heated. Locate and mount infrared heaters so that the area of coverage is limited to the space that the animals occupy.

Use of permanently or semi-permanently installed heaters can help in energy optimization, as these units are designed with better controls and more variability in their output. Wherever use of temporarily mounted infrared heater is necessary energy conservation can be increased by using a proper mounting clamp or hanger which allows the device to be aimed for maximum efficiency.



Frost-Free Waterer

PHOTO: MICHIGAN STATE UNIVERSITY

WATERING

In New Jersey, systems for providing water to livestock consume energy primarily to prevent freezing. Therefore, installation of frost-free fixtures is important in new installations and replacement of broken fixtures. Furthermore, heaters should be thermostatically controlled, and where large troughs are used a dark-colored trough can reduce energy consumption. Above ground plumbing should be insulated, and when heat taping is used to prevent freezing it should be carefully placed between the pipes and insulation.

Expansion tanks for pressurized water systems should be properly sized to reduce pump cycling. Using the largest diameter pipe practical will minimize friction losses and pumping costs. Check watering fixtures and associated plumbing regularly for leaks. Repairing leaks promptly reduces energy wasted in pumping excess water. In dairy operations water used for milk cooling can be used in watering systems, to reduce the energy needed for frost prevention (see “Milk Cooling”).

MOTORS AND MATERIALS HANDLING

Maintain motors regularly and, wherever practical, use high efficiency motors. For larger, frequently used motors with varying loads variable frequency drives can significantly reduce energy consumption. Intermittent and seasonal use motors do not usually contribute significantly to energy use and may be lower priority than other energy consuming devices in livestock operation.

Energy used by conveyors, unloaders, and elevators, can be kept to a minimum through proper lubrication of moving parts and use of NEMA premium-efficiency motors. Efficiency of equipment powered by flexible cords is improved by using cords that are one gauge larger than necessary for a hardwired system.

ANIMAL WASTE MANAGEMENT

There are several possibilities for net energy conservation in management of waste produced by livestock operations. These include reducing energy used in handling wastes and the potential to generate energy from the manure.

Design equipment used for waste collection for the specific type of waste and expected operating conditions. Pump capacity should match the actual quantity of waste moved during typical conditions, and motors should meet current NEMA efficiency guidelines. Size electric wires supplying motors properly to minimize voltage drop.

The energy footprint of mined or manufactured soil fertility additives accounts for the greatest share of United States agricultural energy consumption by energy content, so animal waste products should be used as soil fertility additives whenever possible.

Table 1- Energy Content of Manures in Anaerobic Digestion

Adapted From: Ohio Biomass Energy Program (6)

| Manure Type | Biogas Production/lb. | | Electricity Potential/lb. | Heat Energy/lb. |
|-------------|-----------------------|---------|---------------------------|-----------------|
| | Cu. Ft./Day | BTU/Day | KWH/Day | BTU/Day |
| Swine | 6.04 | 3625 | 0.17 | 2029 |
| Beef | 5.08 | 3050 | 0.14 | 1708 |
| Dairy | 5.11 | 3023 | 0.14 | 1693 |
| Poultry | 7.65 | 4574 | 0.21 | 2561 |

In many smaller operations waste is commonly stockpiled in open storage areas for later application to fields. On larger operations, animal wastes are frequently stored as liquid manures, often in on-farm lagoons. The liquid may be used as a soil fertilizer on the farm or transported off-site. Manure can also serve as an energy source (Table 1). Although dried manure has been combusted for centuries on a small scale for heat, anaerobic digestion is usually the most efficient energy conversion process for wet manures.

Anaerobic digestion systems produce methane gas from animal wastes, and thus represent an opportunity to use these wastes as an energy source (5). The liquid and solid outputs from digesters retain most of the original nutrients of

the feedstock and can be used as soil fertility additives. The main component of anaerobic digestion systems is a sealed storage container, often an in-ground pit or an above-ground tank. Methane produced by anaerobic digestion can be used as a heating fuel for various farm purposes or in some other applications that would normally use natural gas, including electrical generation. Digester gas typically consists of about 60% methane and 40% carbon dioxide. Because of the lower energy content and the presence of other compounds, digester gas may not be suited for all natural gas applications and may need pre-treatment when used in certain types of equipment. Plug-flow digesters are often used in livestock operations in the United States. In plug-flow designs, the material to be digested flows in a linear pattern from the inlet to the outlet, and the effluent is drawn from the entire cross-section of the digester. Plug-flow digesters can use thick wastes (up to 13% solids). Complete-mix digesters use a cylindrical tank with internal agitation. Many waste materials will need to be diluted to a solids level between 2% and 10% for use in complete-mix digesters, but the conversion process is typically more efficient than plug-flow. See NRCS standards for anaerobic digesters (5) for further information.



Plug-Flow Digester
PHOTO: PENNSYLVANIA STATE UNIVERSITY

Anaerobic digesters are generally net energy producers, but there are energy inputs into the process. In addition to the mechanical energy used in mixing and handling wastes, digesters are typically heated to maintain optimal temperatures for the anaerobic organisms which digest the waste. Regular sediment and sludge removal and inspections of the digesters and plumbing (at least twice a year) will ensure that the systems operate efficiently. Using multiple small digesters instead of a single large unit can minimize the downtime associated with sludge removal and cleaning.

Plumbing used in manure management should be appropriately sized for the material being handled to ensure minimal pumping losses. Use large pipes and fixtures with wastes containing high solids and the higher cellulosic content typical of bovine, equine and some other wastes. Wastes from avian and swine sources have a lower solids content and therefore smaller plumbing is acceptable. Pressure drops greater than 30% between a pump and the outlet indicate excess pumping losses. If cleaning the plumbing systems does

not adequately reduce the pressure drop, consider using larger diameter pipes and fixtures. Well- designed plumbing systems will include appropriately placed cleanout fittings.

EQUINE FACILITIES

Horse farms generally have relatively low energy requirements. To the extent that energy is a concern in equine operations, many of the considerations discussed in the preceding sections apply. The major issues are typically related to the needs for providing housing, such as ventilation, heating and lighting. Water supply and waste management may also have energy requirements. Energy used in residences for farm staff (heating, air-conditioning and lighting) is often one of the largest on-farm energy uses.

DAIRIES

Dairy operations have particular energy needs and unique opportunities for energy savings. Milk coolers, water heating and vacuum pumps account for most of the energy use in dairies (4). Technologies that can benefit dairies include variable frequency drives for pump motors, using well water to precool milk using heat exchangers, and using heat recovery from milk tanks to pre-heat water for washing and other purposes. The specific approaches to energy will vary in different operations and there may be economies of scale for some technologies. Vendors of milking parlor equipment can be a valuable resource in selecting, sizing and installing energy conservation equipment. Maximizing milk output per cow can be another way to reduce the energy use per pound of milk produced.

MILK COOLING

Cooling milk accounts for up to 18% of energy used in many dairy operations (4), therefore, the efficiency of milk cooling systems has a large impact on overall energy consumption in dairy operations.



In-Line Plate Cooler
PHOTO: UNIVERSITY OF WISCONSIN

Typically, milk is cooled using mechanical refrigeration, which uses energy to remove heat and wastes both the input energy and the energy in the heat. Recapturing the heat removed from milk reduces the overall energy use in cooling milk. Recovering heat from mechanical refrigeration

equipment for milk tanks for use in pre-heating wash water is often the most effective way to reduce milking parlor energy use.

In-line plate coolers (heat exchangers) are another common method for realizing significant savings in dairies. In-line coolers remove up to 50% of the heat energy from milk before it reaches mechanically refrigerated bulk storage tanks without using mechanical coolers. These heat exchangers may use well water which is re-injected into the ground after passing through the cooler. Alternatively, the water may be in a closed system. In the winter the water used as the heat transfer medium may be used to prevent livestock watering systems from freezing. In warmer months the water can be cooled in large, shallow storage volumes or by evaporative cooling.

Where water-cooled plate coolers are impractical, air-cooled plate coolers can be used, but they are less efficient. The most practical use for the heated air is in heating nearby conditioned spaces.

Proper use and installation of insulation is also critical for energy efficiency in dairies. Bulk storage tanks and refrigeration plumbing should be well-insulated. Plumbing carrying milk which is above room temperature should not be insulated so milk can cool as it is transported.

Proper maintenance of mechanical refrigeration equipment is also critical. Gauges installed on the high and low pressure sides of refrigeration systems allow operators to verify that the system is fully charged, ensuring optimal efficiency. Visible frost or condensation on plumbing components is an indication of heat loss, and these components should be better insulated. Replacing worn compressors prevents energy waste due to internal refrigerant leaks. Select high efficiency equipment when replacing older refrigeration units. See USDA Milk Cooling and Collection systems design research (7) for further information.

MILK COLLECTION

In many instances, variable speed drives will reduce energy use in milk harvesting equipment. Whenever possible, review specifications and installations of variable speed systems with a qualified electrician, agricultural engineer or reliable vendor's representative. Check the calibration of control sensors and speed controllers annually in collection systems with variable speed drives.

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