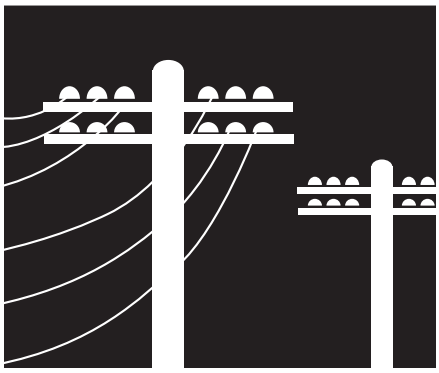
A3784-2



Energy Conservation in Agriculture

Heating Water on Dairy Farms

Scott Sanford

Heating water accounts for about 25% of the energy used on a dairy farm. Hot water is needed for washing the milking system, bulk tank and parlor equipment and possibly for feeding calves and washing towels.

How much water is used and the temperature to which the water is heated directly influences the amount of energy used. Heating water above 165˚F is not usually necessary and wastes energy. A properly adjusted wash system, which minimizes air admissions and uses a warm pre-rinse (100–110˚F), can wash the milking system effectively without excessively high water temperature.

The wash solution flow rate through the milking units for cleaning should be approximately 0.8 gallons per minute (gpm) (3 liters per minute (lpm)) for systems without milk meters and 1.2 to 1.6 gpm (4.5 to 6.0 lpm) for milking systems with milk meters. Refer to manufacturers' recommendations for specific systems.

Excessive flow rates can usually be reduced which in turn reduces water reserve requirements and pumping costs. Oversized milk lines also increase the hot water requirement for washing. Every 1-inch increase in milk line size approximately doubles the hot water needed for washing. This should be taken into account when retrofitting or building a new milking parlor.

Conserving hot water

Reducing energy costs can be as simple as using warm or cold water instead of hot water when possible. Washing a milking system can be accomplished successfully with a warm pre-rinse, a hot wash and a cold acid rinse.

A hot pre-rinse can cause milk to bake on to the milk line rather than rinsing out excess soil load, increasing the soil load of the detergent wash cycle. A warm pre-rinse removes excess soil and warms the milk line so there is less cooling of the wash solution. The purpose of the acid rinse is to control milk stones and other mineral deposits and leave the surface of the pipeline in a state inhospitable to bacteria growth. The thin sheet of acid solution will ideally have a pH in the 2–3 range at the end of the acid rinse cycle. Acid is more active at higher temperatures but since the weak acid solution is allowed to remain on the pipeline surface until the next milking, there is ample time for the acid to dissolve any deposits; therefore, cold water is adequate.

Monitoring the wash water temperature during parlor clean-up can also reduce hot water usage. Cold water is adequate for coarse washing of the parlor and the use of a high-pressure, low-volume power washer can further reduce water use and clean-up time. If warm water is needed, using water directly from a refrigeration heat recovery unit rather than from the water heater will save heating costs.

Dripping faucets are another source of wasted water. One drip per second wastes 48 gallons of water per week.

Water heater ratings

Water heaters are rated differently depending on whether their use is residential or commercial. Residential water heaters are rated using an **Energy Factor** (overall efficiency factor) which takes into account both water heating efficiency (thermal efficiency) and standby losses. Commercial water heaters have a thermal efficiency rating and a separate standby loss factor (% loss per hour). A commercial water heater can be converted to an estimated Energy Factor with the following formula:

EF(commercial) = (%Thermal efficiency x 0.01) ÷ (1+ % standby loss x .24)

Example: Assume a commercial water heater has a thermal efficiency of 80% and standby loss factor of 2.5%.

EF(commercial.) = (80% x 0.01) ÷ (1 + 2.5% x .24)

= (0.8) ÷ (1 + 0.6)

= 0.5

An Energy Factor of 0.5 means that only half of the energy input into the water heater actually resulted on an increase in water temperature. This is the typical efficiency of a standard gas water heater. A commercial water heater with an Energy Factor of 0.61 or more is recommended for dairy applications. A standard water heater that has a thermal efficiency of 80% would need a standby loss % of about 1.0%/hr to have an energy factor of 0.61 or higher. Residential water heaters are not recommended for dairy operations because the thermostats generally have a maximum temperature range of 140°F which may be too low for washing some systems. Commercial water heaters have a thermostat range from 100°F to 180°F.

Residential water heaters also have a **First Hour Rating**, which is the amount of hot water that can be supplied per hour starting with a tank full of hot water. This value is not very useful as water use on a dairy generally occurs over a short period. Most commercial water heater manufacturers' product specification sheets provide a chart with the amount of hot water that can be supplied in time increments; for example 5, 10, 15, 20, 30, 45 and 60 minutes. This data is more useful for determining the right size water heater for an application that uses large quantities over a short period such as the washing of a milking system.

Ratings for water heaters are available from manufacturers or from the Gas Appliance Manufacturers Association and can be found online at http://www.gamanet.org/consumer/certification/certdir.htm.

Purchasing a water heater

There are several things to consider when purchasing a water heater. The first is to choose the type of energy you will be using. The second is to determine the amount of hot water you'll need over a specific period of time. Third, look for a unit with a high Energy Factor rating. The chart below offers some guidance in determining what is considered high efficiency.

Energy Factor ratings

Water heater type	Standard	High efficiency
Electric	0.7 to 0.85	0.91 or more
Gas (LP or natural)	0.4 to 0.5	0.61 or more
Oil	0.5 to 0.6	0.61 or more
Heat pump	N/A	1.5 to 2.0

The water heater tank should be insulated with a minimum of 2.5", preferably 3" of foam insulation or an R-value of R-16 or higher. Fiberglass insulation is not recommended because of the moisture and rodent issues. The outer cover should be a non-corrosive material such as stainless steel or plastic if it is to be located in an area that gets washed down.

Sizing a water heater

The hot water needs for milking system and bulk tank cleaning and other uses such as calf feeding and parlor cleanup must be taken into account when sizing a water heater. In Wisconsin, a minimum water heater tank capacity of 75 gallons is required per regulation by the Wisconsin Department of Agriculture, Division of Food Safety. This size will meet the requirements of many smaller dairies but this needs to be verified before purchasing.

The typical wash cycle uses a warm pre-rinse consisting of half hot water, a detergent wash that is 100% hot water and a cold acid rinse. Therefore, the milk pipeline wash system hot water requirement will be 1.5 times the quantity of water used per cycle.

Since the time difference between pre-rinse and detergent wash cycles is only 5 to 10 minutes, it should be assumed that the need is all at once. The main assumption is that the hot water supplied for the pre-rinse cycle will not be ample to start the water heater reheating.

Bulk tank cleaning could follow or occur at the same time as CIP cleaning, depending on the milking schedule. If it follows milking, then 30 minutes of reheat time can be allowed for the water heater. Bulk tanks have cycles similar to the milking system and use an average of 28 gallons per cycle for a 1,500-gallon or smaller tank, and 55 gallons for a 1,600-gallon or larger tank. The hot water requirements will be 1.5 times the quantity of water per cycle.

Example #1

A 100-cow dairy with 8 milking units requires 35 gallons of water per wash cycle and has a 2500-gallon bulk tank that is picked up every other day. The bulk tank is washed 30 minutes after the start of the milking system.

Milking system hot water needs:

35 gallons x 1.5 cycles = 53 gallons

Bulk tank hot water needs:

55 gallons/cycles x 1.5 cycles = 82.5 gallons

Referring to the table below, a 75-gallon water heater will meet the washing needs of the milking system but not the bulk tank if it is washed 30 minutes after the milking system. In 30 minutes the 75-gallon water heater can only supply 86 gallons of heated water. A 100-gallon water heater will only meet the needs if the bulk tank is washed 60 minutes after the start of the milking system wash. If water is pre-heated with a refrigeration heat recovery unit to 110ºF, then the 75-gallon water heater would have about twice the capacity and be sufficient for this system.

Water heater information for examples 1 and 2

75-gallon LP Water heater delivery rates for a 100ºF temperature rise:

Time (min.)	5	10	15	20	30	45	60
Gallons	58	64	69	75	86	103	119

Recovery capacity 50˚F temperature rise—127 gallons/hr.

100-gallon LP water heater delivery rates for a 100ºF temperature rise:

Time (min.)	5	10	15	20	30	45	60
Gallons	76	81	87	92	103	120	137

Recovery capacity 50˚F temperature rise—127 gallons/hr.

Example #2

A 500-cow dairy uses 75 gallons of water per cycle and has a 5000 gallon bulk tank that is emptied daily. There is 1.5 hours between milkings and water is preheated to 110ºF using a refrigeration heat recovery unit.

In this case the milk line and the bulk tank must be assumed to be washed at the same time.

75 gallons/cycle x 1.5 cycles
+ 55 gallons/cycles x 1.5 cycles
= 195 gallons

65 gallons will be initially used
followed by 130 gallons
10 minutes later.

In this case two 100-gallon water heaters would be the minimum recommended and if calves were to be fed using the same hot water source within an hour of washing, additional water heaters would be needed.

These examples do not take into account hot water used for cleanup of the parlor.

Reducing standby losses

Standby losses occur when heat in the water is conducted out through the wall of the water heater or when thermo-siphoning sends water up the pipes above the water heater and heat is conducted to the surrounding environment.

There are several things that can reduce standby losses in an existing water heater. If the water heater has an R-value (resistance to heat conduction) of less than 16 and is located in a dry spot, a water heater insulation kit can be purchased and installed. The kit comes with fiberglass insulation bonded to a plastic film that can be wrapped around the tank and taped in place to add extra insulation. Electric water heaters can be insulated on the top and sides but gas and oil water heaters are generally insulated only on the sides to provide the proper clearance between the hot flue and the plastic film, which could melt. Follow the manufacturer's instruction for the kit. Heat can be maintained in pipes leaving the water heater by installing foam insulation and a heat trap on the hot water pipe leaving the water heater. This decreases thermo-siphoning of hot water from the water heater, resulting in reduced losses. Insulating water pipes from the water heater to the end use will help maintain water temperature before it reaches the intended use.

For more information

Information on different technologies and energy conservation opportunities are contained in the *Energy Conservation in Agriculture* publication series, available from Cooperative Extension Publications at http://cecommerce.uwex.edu.

Author: Scott Sanford is a senior outreach specialist with the Department of Biological Systems Engineering at the University of Wisconsin–Madison.

This publication is funded in part by the *Wisconsin Focus on Energy* Program.

To order multiple copies of this publication, call toll free: 1-877-WIS-PUBS (947-7827).

To see more Cooperative Extension publications, visit our web site: cecommerce.uwex.edu

Energy Conservation in Agriculture: Heating Water for Dairy Farms (A3784-2) **I-09/2003**