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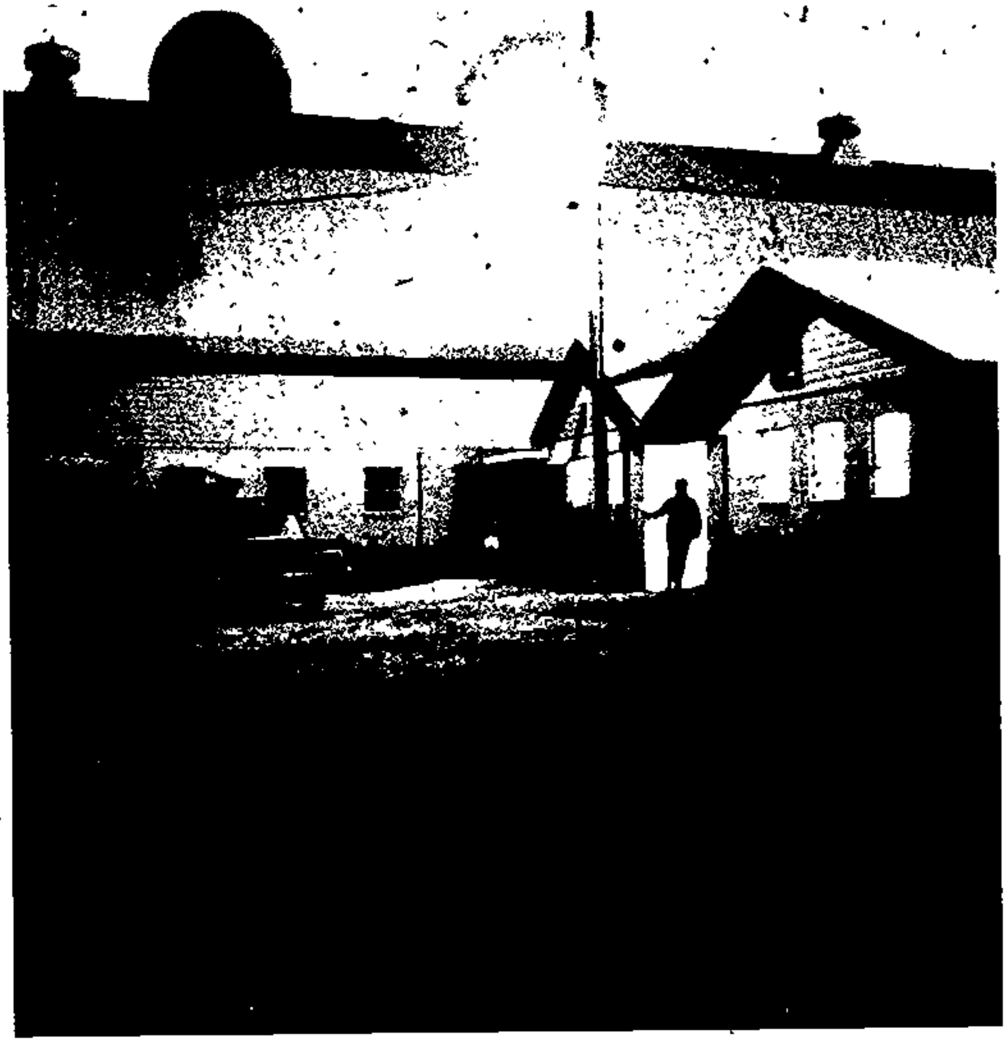
ABSTRACT

This booklet gives a brief overview of energy use patterns in a dairy farm and gives tips on cutting costs of water heating, ventilation and supplemental heat, milk cooling, vacuum pumps, electric motors, tractors, trucks, engines, and lighting. Finally, energy use recordkeeping is discussed. (BB)

A GUIDE TO ENERGY SAVINGS FOR THE DAIRY FARMER



UNITED STATES
DEPARTMENT OF
AGRICULTURE

FEDERAL
ENERGY
ADMINISTRATION

ONE PART OF A SERIES OF PUBLICATIONS ON ENERGY AND U.S. AGRICULTURE

This report was prepared by Gary G. Frank, Dairy Program Area, Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. It was prepared under the supervision of George B. Rogers, Energy Coordinator, Commodity Economics Division, Earle E. Gavett, Energy Coordinator, National Economic Analysis Division, Economic Research Service, and Robert C. Marlay, Technical Project Officer, Federal Energy Administration.

Other publications in this series are A Guide to Energy Savings for the Livestock Producer, A Guide to Energy Savings for the Field Crops Producer, A Guide to Energy Savings for the Vegetable Producer, A Guide to Energy Savings for the Poultry Farmer, and A Guide to Energy Savings for the Orchard Grower.

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Organizations: American Farm Bureau Federation, Dairy Research, Inc., National Council of Farmer Cooperatives, National Dairy Council, National Farmers Union, National Grange, National Milk Producers Federation, Milk Industry Foundation, United Dairy Industry Association.

Individuals: Donald [illegible] Price, Cornell University; John R. Schmidt, University of Wisconsin; C. Ray Hogland, Michigan State University; Francis Gilman and George Frick, University of New Hampshire; L. B. Altman, Lowell E. Campbell, Frank W. Dickinson, Paul D. Thompson, R. G. Yech, O. U. Bay, and Pat Ralston, U.S. Department of Agriculture.

The contributions of State and Federal Extension and research personnel to this guidebook in the form of research bulletins, Extension publications, notes, and conversations have been extremely helpful. Many of these contributions are directly acknowledged in the text of the report. Data and assistance from dairy industry sources also are greatly appreciated.

* Listing does not imply official endorsement of the guidebook nor complete agreement with its contents.

JUNE 1977

CONTENTS

The Nation's 2½ million farms consume 6.3 billion gallons of gasoline and diesel fuel, some 173 billion cubic feet of natural gas, 1.5 billion gallons of LP (liquified petroleum) gas, and 32.3 billion kilowatt-hours of electricity in a typical year.

While amounting to only 3 percent of all the energy used in the country, the energy required to keep our farms in operation is a vital and increasingly expensive resource. The cost of energy has nearly doubled in the last 10 years. The largest part of the increase has taken place in the last 3 years alone.

Farmers are coping with higher costs for energy in the same way they deal with other problems that arise. They are adjusting operations to get the last drop of value out of a gallon of fuel, to wring more work out of a kilowatt-hour of electricity.

Beyond the need to save money, farmers may well ask why they should be expected to be more conscientious about conserving energy; cost-consciousness is built into any successful farm operation. But farmers, like the rest of the Nation, are being forced by global energy problems to reassess their use of fossil fuels. The entire Nation is being made increasingly aware of the severe limits of what was once thought of as a limitless resource. For all to prosper, all must conserve, no matter how great the individual priority of use.

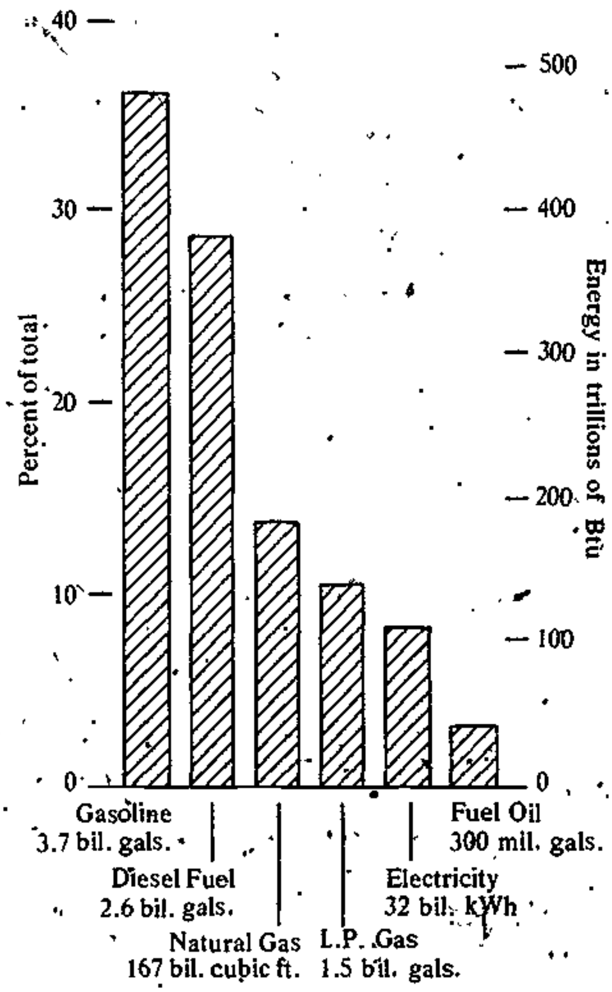

Figure 1. ENERGY USED IN AGRICULTURE (1974)

This guidebook contains a wide spectrum of ideas for operators of many sizes and types of farms, operators whose conception of energy conservation may vary. The ideas range from greater attention to daily details to substantial added investments in facilities and equipment. Not all the ideas will yield large dollar savings. Today energy conservation may seem secondary to other considerations because energy costs remain a small fraction of total costs. Tomorrow, as available quantities of energy become restricted, producers will have to adopt energy conservation measures irrespective of cost.

This effort is to help farmers to use energy resources even more prudently in the future.

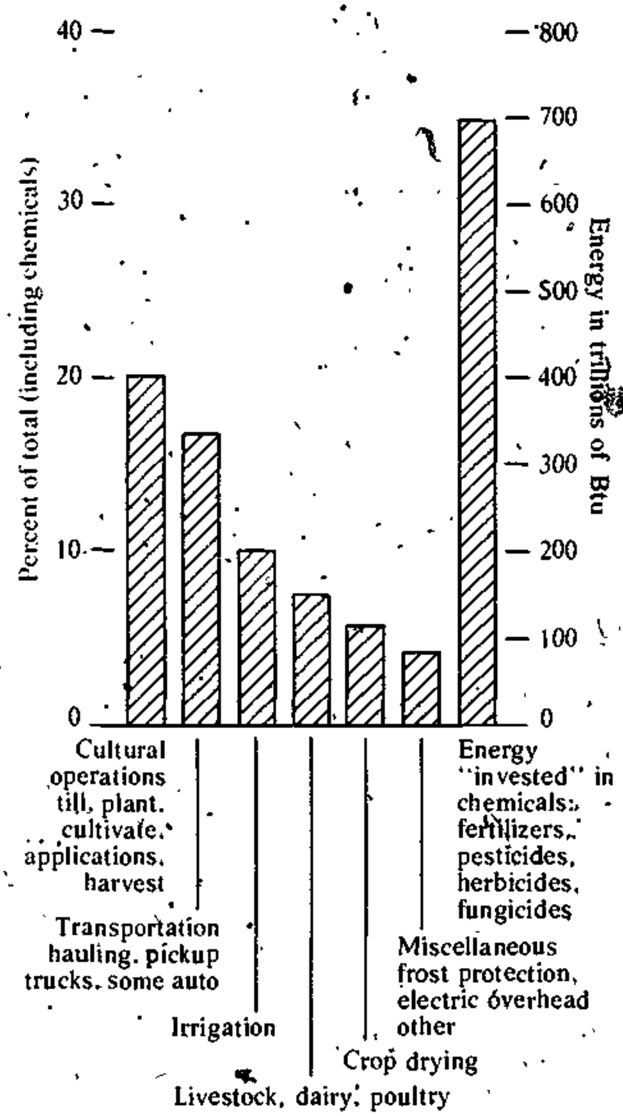

Figure 2. ENERGY USED IN AGRICULTURE, PLUS FERTILIZER AND CHEMICALS (1974)

Table 1--Energy used in U.S. agriculture, by commodity, 1974 1/

Commodity	Inventory 2/	Gallons of gasoline	Gallons of diesel	Gallons of fuel oil	Gallons of LP gas	Ft.^{3} of natural gas	kWh of electricity	Total Btu
		Thousands				Millions		Billions
Total dairy	11,220	218,318	3/	3/	76,506	4/	5,105	51,981
Other livestock	NA	599,047	352,416	8,817	256,379	4,525	4,923	172,310
Total livestock	NA	817,365	352,416	8,817	332,885	4,525	10,028	224,291
Total crops	340,595 5/	2,881,276	2,286,539	295,112	1,148,657	159,500	22,060	1,789,930
Total agriculture	NA	3,698,641	2,638,955	303,929	1,481,542	164,125	32,088	2,014,221

1/ Data include all energy used directly on the farm for crop and livestock production purposes--field operations, irrigation, crop drying, mechanized feeding, space heating, farm business auto use, etc. Numbers may not add up to totals due to rounding.

2/ Harvested acreage except for planted acreage in the following: rice, rye, winter wheat, spring wheat, oats, barley, cotton, soybeans, peanuts, flaxseed, dry edible beans, dry edible peas, sugar beets, and sweet potatoes.

3/ Included as gasoline-equivalent.

4/ Included in LP gas.

5/ Thousand acres.

Historically, most forms of energy have been inexpensive for dairymen. Recent price increases, however, have changed that, fostering a need for energy-efficient management and technology.

Presently, milk production per cow in the United States requires about 550 kilowatt-hours of electricity, about 6 gallons of LP gas, and 10 gallons of gasoline equivalent annually. This equals an energy cost per cow of approximately $35.

Some dairymen feel they are already as efficient as is practicable, but opportunities exist in every operation to save energy and money. Energy-saving ideas are offered in the following chapters. Some of these ideas require no investment to save energy and money. Others require up to 7 years for the dollars saved to pay for the investment needed to conserve energy. Some of these ideas should help you now or in the future if you plan to expand or make a major change in your operation.

The recordkeeping section gives some estimates of energy use for different farm tasks. While these estimates may not be exactly correct for your farm, they are reasonably accurate since they are based on personal interviews with dairy farmers and on State experiment station data. By comparing your energy usage for a particular task with the estimates, you may discover ways to cut costs.

Through careful management, a dairy farmer may save 10-20 percent of the energy he uses now. For a 50-cow operation, this means a savings of $175-$350 per year at 1975 prices. Where energy conservation requires additional investment or a major change in management practices, consult a local or university Extension agent.

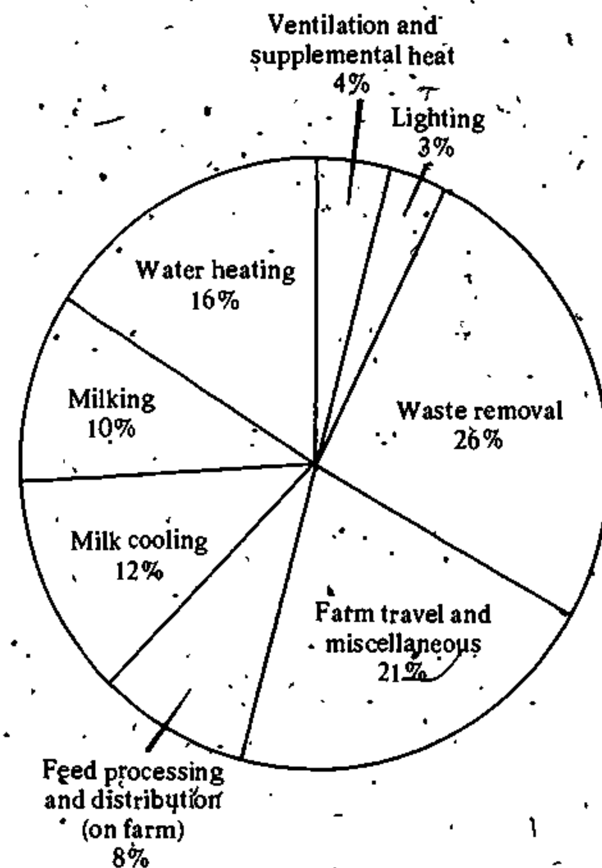

Figure 3. PERCENT OF THE BTU ENERGY USED IN DAIRY FARMING

Water heating accounts for 16 percent of purchased energy on the average dairy farm. Cost of electricity for water heating can vary from 3¢ to 6¢ per kilowatt-hour, depending on the locality. With management and planning, the average dairy farmer can save from $40 to over $200 a year on water heating bills.

Udder washing and utensil sanitation require lots of hot water. Heating water can take as much as 25 percent of the total electricity used on a dairy farm. Where propane or oil is used, 80 to 90 percent of the fuels purchased for the farm operation goes to water heating.

Table 2--Average annual energy required for water heating in a 50-cow dairy operation

Item	Amount	Cost (dol.)
Electricity	8,750 kWh	350
LP gas	550 gal	165
Electricity requirement to heat water for prep stall	7,750 kWh	310

WATER HEATING

It is possible to save energy in water heating and still maintain high sanitation standards. For example, some dairymen are using solar heat to preheat water before it enters the water heater. Other dairymen are utilizing waste heat from bulk tank compressors and vacuum pump motors for preheating water.

Water heaters provide hot water in one of two ways: by heating the water to the right temperature for a particular use or by heating the water to a high temperature and later mixing in cold water to achieve the desired temperature. Some dairymen use two water heaters: one for udder washing and general use, and the other for sanitizing milking utensils and pipelines. This saves energy by reducing heat loss in the distribution lines and through the sides of heaters.

No matter how closely the hot water system is watched, some energy losses are inevitable. But they can be minimized. The table below lists some sources of energy losses and adjustments necessary to correct them.

ENERGY SAVING TIPS

Major Change

Consider the following before replacing or installing a water heating system:

-- Hot water heater's efficiency in energy use.

--The different temperatures and volumes of hot water needed for washing or sterilization.

--Availability and cost of different fuels.

--Two small heaters versus one large one.

Install separate water heaters near the place where the water is to be used, thus reducing energy loss along distribution pipes.

Install the distribution line at a level lower than the place where the water leaves the water heater. This prevents continuous circulation of cooler water out of the distribution pipe back into the heater. If the distribution line must be hung from the ceiling, install a U-shaped trap to prevent recirculation and reheating.

Buy a heater with maximum insulation.

Routine Maintenance

Fix dripping hot water faucets--one drip per second will waste 10 or more gallons of hot water a day, and will cost more than $30 per year.

Minimize use of hot water--every time water is used there is a heat loss from hot water in the distribution pipes.

Don't overheat the water--it only accelerates needless heat transfer and loss.

Install spring-operated valves on faucets that are most heavily used--an automatic shut-off may prevent the loss of many gallons of hot water every day.

Use cold water wherever possible for platform and floor cleaning.

Check the float in the pipeline rinse tank--a maladjustment can waste 5 to 10 gallons of hot water per day.

Insulate hot water distribution lines with at least three-fourths of an inch of pipe insulation.

Table 3--Energy loss in hot water heating

Type of water heater	What to check for	Source of loss	Adjustments necessary
Electric, gas, or oil	Local hot spot	Heat loss through surface of unit	Have insulation checked
Gas or oil	Smoky exhaust	Unburned fuel	Adjust burner
Gas or oil	Hot stack	Excessive stack temperature	Adjust burner and clean or flush heater
Electric, gas, or oil	Missing or damaged insulation on pipes	Water cooling in distribution pipes	Add insulation to hot water pipes

EXAMPLE OF CUTTING COSTS BY DRAINING AND FLUSHING WATER HEATERS — $72.77 energy savings per year for a 50-cow dairy with a pipeline milking system.

Drain and flush the water heater every 6 months. With normal use, water heaters accumulate solids that prevent efficient transfer of heat to water. These deposits can be removed by flushing the sediment out of the heater. To do so, open the drain valve and drain 2 to 5 gallons of water from the tank, or drain until the water runs clear. In areas where the water is extremely hard, it is advisable to flush the systems monthly.

The cold start efficiency of an electric water heater is approximately 90 to 95 percent: 3.7 to 3.9 gallons of water heated per kilowatt-hour. The efficiency may drop as deposits form in the bottom of the heater's tank. Some poorly maintained electric water heaters heat less than 3 gallons of hot water per kilowatt-hour.

NOTE: A requirement of 125 gallons of hot water per day for a 50-cow herd may seem like a lot, but 80 gallons are required per day just to wash the pipeline. It is assumed in this example that the incoming water's temperature is 100°F lower than the outgoing (hot) water's temperature.

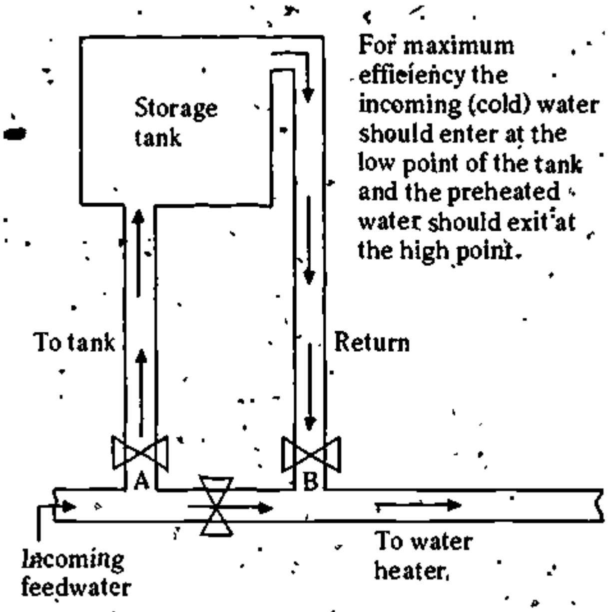

Figure 4. PREHEATING WATER HEATER'S FEEDWATER

Calculations

Clean system

125 gal/day x 365 days/yr = 45,625 gal/yr.
45,625 gal x 1 kWh/3.8 gals (near maximum efficiency) = 12,007 kWh/yr
12,007 kWh/yr x $.04 = $480.26/yr

Dirty system

45,625 gal x 1 kWh/3.3 gals = 13,826 kWh/yr
13,826 kWh/yr x $.04 = $553.03/yr
$553.03 - 480.26 = $72.77 savings/yr.

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$54.57	$72.77	$90.95	$109.14

EXAMPLE OF CUTTING COSTS BY USING THE WASTE HEAT FROM THE BULK TANK COMPRESSOR TO PREHEAT WATER

$205 energy savings per year for a 50-cow dairy.

Thirty million Btu's per year are removed from the milk produced by a 50-cow herd with a 12,000-pound average in order to cool the milk to 38°F. On most dairy farms these Btu's are lost, and additional Btu's are purchased to heat water.

A heat exchanger, which can be purchased for about $600 (plus $50 for installation), can capture most of this waste heat. A study at Cornell has shown that 37-44 percent of the energy used to heat water can be saved through the use of a heat exchanger. 1/ Also, because the exchanger causes a better transfer of heat out of the refrigerant, 5-19 percent of the energy required to cool the milk is saved.

1/ Turner, C.N. and Richard H. Paft, "Bulk Milk Cooler Heats Water." Progress report to the New York Farm Electrification Council, Cornell University, Ithaca, New York, 1959.

Calculations

Water heating

125 gal/day x 365 days/yr = 45,625 gal/yr
45,625 gal x 1 kWh/3.5 gal (average efficiency) = 13,036 kWh/yr
13,036 x $.04/kWh = $521.44/yr
$521.44 x 37 percent savings = $192.93/yr

Milk cooling

120 cwt/cow x 50 cows = 6000 cwt/yr
6000 cwt x 1 kWh/cwt = 6000 kWh/yr
6000 kWh x $.04/kWh = $240.00/yr
$240.00 x 5 percent savings = $12.00/yr
$192.93 + $12.00 = $205/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$154	$205	$256	$307

EXAMPLE OF CUTTING COSTS BY SOLAR PREHEATING THE WATER HEATER'S FEEDWATER

$105 energy savings per 50-cow dairy for a 7-month period

Some dairy farmers in the Southwest preheat the water heater's feedwater with solar heat. The process requires the installation of a sealed tank that holds slightly more water than the amount of hot water used daily. The tank should be painted black to aid in heat absorption from the sun. It must be placed directly in the sun.

To install the tank, cut the incoming water line. Put in valves and tubing to make the tank part of the incoming line (as indicated). Valves are necessary where the tank must be drained in winter to prevent freezing. Valves A and B are open and valve C closed during the warmer months of the year. Reversing the valves in winter will allow the water to enter the water heater without first flowing through the tank.

A setup like this could preheat water by 35°F (50°F to 85°F), on the average, for at least 7 months of the year, even in cold areas. Water is normally heated 100°F to a temperature of 150°F; therefore, this would be a saving of 35 percent during those 7 months, or $105.

The cost of the tank, piping, valves, and installation will vary with region and how much work is done by the dairyman, but it should not exceed $200. Before installing a tank, check with an Extension agent and fieldman to see if there are any laws or codes against it. If not, do a break-even analysis before making the final decision.

Calculations

125 gal/day x 30 days/month = 3,750 gal/month
3,750 gal/month x 7 months = 26,250 gal
26,250 gal x 1 kWh/3.5 gal = 7,500 kWh
7,500 kWh x $.04/kWh = $300.00
$300.00 x 35 percent savings = $105.00

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Savings (7 months)	$78.75	$105.00	$131.25	$157.50

EXAMPLE OF CUTTING COSTS BY REPAIRING DRIPPING HOT WATER FAUCETS

$42.00 energy savings per year per dripping hot water faucet

A dripping water faucet wastes 10 or more gallons of water per day. If this is a cold water faucet, the pumping energy wasted is quite small. However, if it is a HOT water faucet, considerably larger amounts of energy are wasted. The cost of fixing a dripping faucet is a little time plus a washer costing 15 cents or less.

The calculations assume that 1 kilowatt-hour will pump 500 gallons of water. Deep wells will require more energy per 500 gallons.

Calculations

Cold water pump

10 gal/day x 365 days/yr = 3,650 gal/yr
3,650 gal x 1 kWh/500 gal = 7.3 kWh/yr
7.3 kWh x $.04 kWh = $.29/yr

Hot water loss

10 gal/day x 365 days/yr = 3,650 gal/yr
3,650 gal x 1 kWh/3.5 gal = 1,043 kWh/yr
1,043 kWh x $.04/kWh = $41.71

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$31.50	$41.71	$52.50	$63.00

EXAMPLE OF CUTTING COSTS BY A CAREFUL SETTING OF THE THERMOSTAT ON THE WATER HEATER

$89.20 energy savings per year for a 50-cow dairy with a pipeline milking system

If the thermostat on the water heater is set at 165°F when local standards require 145°F, you are wasting energy.

Heating 125 gallons of water a day by an extra 20°F requires an extra 6.1 kilowatt-hours of electricity a day, or 2,230 kilowatt-hours per year. At 4 cents per kilowatt-hour, the extra 20°F would cost the dairyman about $90 a year. Also, there is a greater heat loss through an entire system when it operates at temperatures higher than local standards require.

Calculations

165°F - 145°F = 20°F
125 gal/day x 365 day/yr = 45,625 gal/yr
45,625 gal x 8.34 lb/gal = 380,512 lb/yr
1 Btu/lb/1°F x 20°F = 20 Btu/lb
380,512 lb x 20 Btu/lb = 7,610,000 Btu/yr
7,610,000 Btu x 1 kWh/3,413 Btu = 2,230 kWh/yr
2,230 kWh x $.04/kWh = $89.20/yr savings

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$66.90	$89.20	$111.50	$133.80

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Costs can be cut by conserving the power used to ventilate or heat space. Turning off a pilot light during the summer can save $14 a year; adding insulation or reducing ventilation can save $70 to $200 a year.

The electrical power needed to ventilate a nonbanked warm barn can be as high as 40 kilowatt-hours per cow per month during the summer. This converts to $1.60 or more on the individual electric bill and $80 a month for a 50-cow dairy operation.

Ventilating a dairy barn helps to remove heat and moisture. During the summer, there is enough heat to remove moisture. But in winter, heat loss through walls and roof can cause moisture condensation in the barn. One remedy is supplemental heat. A second, and much less energy-intensive method, is better insulation. A general rule for the operation of a dairy barn should be: If you ventilate, insulate.

The amount of insulation to install in a dairy barn depends on the cost of the insulation relative to its R-value (see table on page 14), the climate, and fuel costs. Note that the cost involved in insulation is substantial. It can be a dollar or more per square foot of floor space, depending on building size and insulation used. Check with the local Extension agent to determine the break-even point between the costs of additional insulation and a lower energy bill.

Table 4--Average annual energy required for ventilation and supplemental heat (per 50-cow herd)

Item	Amount	Cost (dol)
Ventilation	14,000 kWh	560
Supplemental heat		
Electricity	2,000 kWh	80
Propane gas	120 gal	36

ENERGY SAVING TIPS

Major Change

Look carefully at ventilation and supplemental heating needs. A warm freestall barn may provide a better environment for dairy cows than does a cold barn. But electricity usage per cow can be as much as 100 percent higher in a warm barn.

Insulate the milkhouse to cut supplemental heating and ventilation needs.

Routine Maintenance

Operate fans only when necessary, not continually.

Operate fan switches manually in the summer if cows are pastured or fed outside.

Check and oil fan motors regularly.

Check to be sure that your multispeed fan motor is not of the resistance element type which draws the same amount of current whether it is operating at low or full speed.

Check and clean all heating systems. Turn off the whole system in the summer, pilot light included.

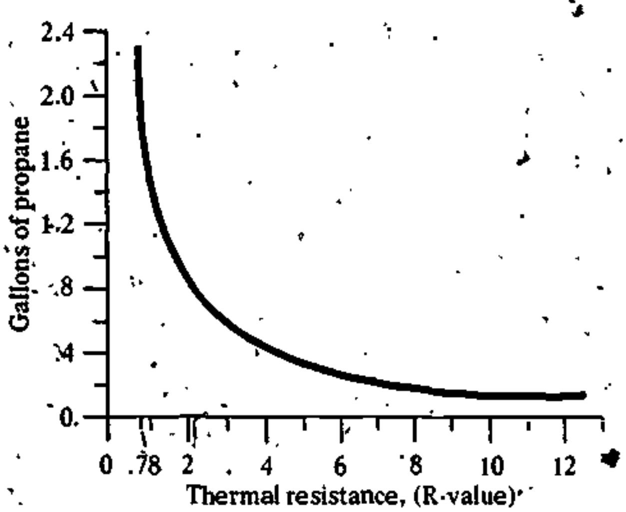

Figure 5. GALLONS OF PROPANE REQUIRED PER WEEK TO COMPENSATE FOR THE B.T.U. HEAT LOSS PER 1,000 SQ. FT. OF EXPOSED ROOF OR WALL AREA PER 1°F DIFFERENCE BETWEEN INSIDE AND OUTSIDE TEMPERATURE, AT DIFFERING R-VALUES

Source: Verel Benson, ERS-CED, personal communication.

Note: The R-value of a material is a measure of its ability to resist heat flow. The .78 R-value is the sum of the inside (.61) plus the outside (.17) film's R-values. Therefore any type of wall or roof has at least this R-value.

Figure 5 and the following table are inserted to provide you with additional information of insulation. Your parlor and milkhouse should be insulated. The amount of insulation you should install depends on the cost of the insulation (relative to its R-value), the climate in your area, and fuel costs. Consult your Extension agent for more information on the break-even between insulation and fuel costs in your area.

The following table presents the relative R-values of a number of commonly used construction and insulating materials. The insulation value of some of the materials is greatly reduced by moisture, thus it is important that a proper vapor barrier be installed to prevent the moisture in the barn from penetrating the insulation.

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Insulation value of materials

Material	R-Value 1/
Air space, enclosed by ordinary materials	0.91
Air space, aluminum foil one side	2.17
Air space, aluminum foil both sides	2.44
Surface film, inside, nonreflective	0.61
Surface film, inside, reflective	1.10
Surface film, outside, 15 mph wind	0.17
Asbestos-cement board (1/8")	0.03
Gypsum board or sheet rock (3/8")	0.32
Gypsum board or sheet rock (1/2")	0.45
Plywood (1/4")	0.31
Plywood (3/8")	0.47
Plywood (per inch)	1.24
Blanket insulation, mineral wool (per inch)	3.70
Loose fill insulation, wood fiber (per inch)	3.33
Loose fill rock wool or glass wool (per inch)	3.70
Loose fill, vermiculite, expanded (per inch)	2.13
Sawdust or shavings (per inch)	2.22
Foam insulation, expanded polyurethane (per inch)	6.25
Foam insulation, expanded polystyrene (per inch)	4.00
Common brick (4")	0.80
Face brick (4")	0.44
Clay tile (4")	1.11
Clay tile (8")	1.85
Concrete blocks, regular (8")	1.11
Concrete blocks, light weight (8")	2.00
Concrete, regular (8")	0.64
Sheathing or flooring, softwood (3/4")	0.94
Sheathing or flooring, hardwood (3/4")	0.68
Drop siding, 1 x 8	0.79
Bevel siding, 1/2 x 8	0.81
Bevel siding, 3/4 x 10	1.05
Building paper	0.06
Roll roofing, asphalt	0.15
Builtup roofing (3/8")	0.33
Asphalt shingles, 3 tab (3/8")	0.44
Wood shingles, 7 1/2-inch exposure	0.87
Metal roofing	Negligible
Window, single glass	0.10
Window, single glass with storm sash	1.54
Roll side wall curtin	Negligible

1/ Thermal resistance rating.

SOURCE: Carr, Lewis and Felton, Kenneth E., and Nicholson, James L., Planning for Fuel Conservation in Your Broiler House, Cooperative Extension Service, Univ. of Md., College Park, Md., 1974, MEP 302.

EXAMPLE OF CUTTING COSTS IN COLD VERSUS WARM FREESTALL BARN

$408 energy savings per winter season in a cold barn for a 100-cow dairy

Many dairymen are surprised by increases in their electric bills when they build new warm freestall barns. The higher cost is often attributed to an increase in cow numbers, but most of the cost increase is due to a change in the system. Requirements per month for ventilating a 100-cow warm freestall barn vary from 1,770 to 2,540 kilowatt-hours, with an average of 2,040 kilowatt-hours. The cost of this electricity will run from $60 to $120 per month. The ventilation cost of the old system may have been zero. The energy cost of ventilating a warm freestall barn with slated floors for a liquid manure system will be even higher, averaging 2,780 kilowatt-hours monthly.

Production per cow may be slightly higher in warm (confined environments) barns. This additional production might offset the increase in the electrical bill at current prices. But you must also include the additional investment cost, which is $150-$200 per cow, above that required for a cold barn.

Carefully evaluate not only the production efficiencies of various types of barns in relation to investment but also the energy efficiencies. The increasing cost of energy could change the outcome of the analysis.

Calculations

2,040 kWh/month x 5 months = 10,200 kWh

10,200 kWh x $.04 = $408

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Savings (per winter)	$360.00	$408.00	$510.00	$612.00

EXAMPLE OF CUTTING COSTS BY SHUTTING OFF THE PILOT LIGHT ON A SPACE HEATER

$14.00 energy savings per summer season.

The pilot light on a space heater burns 5 or more gallons of LP gas per month. This energy is not wasted in the winter months when the heat is needed in the parlor or milkhouse. In the summer months, however, this heat is not needed and energy dollars are wasted. The whole system can be turned off by shutting off the valve between the storage tank and the gas line leading to the space heater.

One dairy farmer in Ohio had a monthly LP gas bill of $5-$6 in the summer before turning off his entire space heating system, pilot light included. After shutting down the entire system, his bill was zero.

Calculations

5 gal/month x 7 months = 35 gal
35 gal x $.40/gal = $14.00

EXAMPLE OF CUTTING COSTS BY REDUCING VENTILATION IN STANCHION BARNS DURING THE SUMMER

A barn with a 70-cow tie stall operation was ventilated by four fans that produced at the rate of 7,000 cubic feet per minute. Each was operated by a 3/4-horsepower electric motor. The cows were fed outside during the summer. They usually were let out of the barn after the morning milking and brought back into the barn in the middle of the afternoon. The fans kept running while the cows were outside. In fact, the dairyman said all four fans ran 24 hours a day during the summer. In winter only one fan ran continuously.

Such continuous operations in the summer not only waste energy but also heat up the barn because warm air from outside is drawn into the barn. Turning off fans when the cows are outside would reduce energy use by about 5,332 kilowatt-hours, or the cost by more than $210 for a summer.

The barn in the above example contained no young stock. If a barn has some young stock or a sick cow in it, perhaps one fan should be kept running.

One small fan operating continuously consumes more energy than is used on most dairy farms for the entire mechanized feeding system. A 1/3-horsepower motor running continuously consumes 7,246 kilowatt-hours per year. This can cost almost $290. Do not be misled by claims of only pennies per hour because there are 8,760 hours in a year.

$213.29 energy savings per summer	season for a 70-cow dairy

Calculations

(4 3/4-hp motors)

7 h/day x 120 days = 840 h
3/4 hp x 2.116 kW/hp = 1.587 kW/motor
1.587 kW/motor x 4 motors = 6.348 kW
6.348 kW x 840 h = 5,332 kWh
5,332 kWh x $.04/kWh = $213.29

(1 1/3-hp motor)

1/3 hp x 2.484 kW/hp = 0.828 kW
0.828 kW x 8,760 h/yr = 7,253 kWh
7,253 kWh x $.04 = $290/yr

Savings at Different Electrical Rates (3/4-hp motor)

Cents/kWh	3¢	4¢	5¢	6¢
Savings (per summer)	$159.97	$213.29	$266.61	$319.94

EXAMPLE OF CUTTING COSTS BY INSULATING PARLORS AND MILKHOUSES

$70.00 energy savings per year for a milkhouse in New York State

Adding insulation to existing walls is difficult, and in some cases impossible. In new buildings as much insulation as possible should be put into the walls. Insulation to an "R" value of 12 to 14 is recommended. (See table on page 14.) The ceilings of existing buildings, which can usually be insulated with little difficulty, should be insulated to an "R" value of 16 or more. Most floors are concrete slab and no insulation can be added. When building a new structure, use crushed rock, or a substance that will add dead air space, below floors to act as insulation. Caulking windows and weather-stripping doors will hold in the heat in winter and keep the heat out in summer.

A 12- by 20- foot uninsulated parlor will require nearly twice as much heating and cooling as one that is properly insulated. In New York, heating an uninsulated parlor consumes over 150 gallons of propane during a typical winter, and 2,000 kilowatt-hours of electricity for ventilation in the summer. While the cost involved in insulation is substantial, it could cut in half the amount of propane and electricity needed and save more than $70 in energy costs. The local Extension agent can provide more information on the break-even point between insulation and fuel costs.

Calculations

150 gal x $.40/gal = $60.00
2,000 kWh x $.04/kWh = 80.00
$140.00

Save 1/2 with proper insulation.

$140 x 1/2 = $70.00

Insulation Cost

Parlor area is 12' x 20' = 240 sq. ft.
Average cost per square foot = $1.00
240 sq. ft. x $1.00 = $240

Average annual energy required for milk cooling (per 50-cow herd)

Number of kilowatt-hours	Cost (dol)
6,000	240

Milk cooling may require 10 to 15 percent of the energy used in typical dairy operations. While this percentage is not a major share, the efficiency of a milk cooling operation deserves close attention because it uses the most expensive form of energy--electricity.

The cost of electricity averages about 4 cents per kilowatt-hour. At this rate, energy purchased in the form of electricity costs 3 to 4 times as much as the same amount of energy from other fuels, such as LP gas and diesel fuel.

Two kinds of refrigeration equipment are used by dairy farmers to cool milk--ice builders and direct expansion coolers. The direct expansion coolers generally require a larger compressor than the ice builder types, but they use less energy per unit of milk cooled. Three factors cause the ice builder to need more energy:

--An extra motor is needed to circulate the ice water.
--The compressor must operate intermittently to keep the ice bank built.
--When the bulk tank is empty, the sides of the ice bank cooler are kept at the cool shutoff temperature; the direct expansion cooler is completely shut off, and its sides are allowed to warm to room temperature.

The disadvantages of the ice builder may be offset when lower rates for electricity are offered during "off peak" demand periods, such as early morning and evening. When this occurs, the ice builder may actually be more economical than the direct expansion cooler.

ENERGY SAVING TIPS

Major Change

Purchase a bulk tank that is large enough for the herd and the most efficient in terms of energy needs. Direct expansion units are more energy-efficient unless rate discounts for off-peak usage are offered.

Ask about the type of refrigerant a cooler uses. The type affects the amount of back pressure that can be allowed to achieve a desired temperature. The higher the back pressure, the more energy-efficient the equipment.

Put a bulk tank compressor to good use by ventilating the compressor heat going into the parlor during winter and outside during summer. This waste heat can also preheat water, thereby reducing your water heating bills.

Routine Maintenance

Check and oil the electric motor when necessary.

Check the alignment and condition of the compressor and fan belts and the tightness of the belt.

Keep the fins on the compressor head clean and free of buildup.

Clean the screen or other material covering the vent outlet.

Make sure the compressor head is adequately ventilated; don't restrict the air flow. The condensing unit should be 18 inches or more away from the wall.

Keep condenser coil clean.

EXAMPLE OF CUTTING COSTS BY PROPER MAINTENANCE OF THE MILK COOLER

$24.00 energy savings per year

for a 50-cow dairy with a 12,000 pound herd average

Refrigeration is accomplished through evaporation of a liquid with a low boiling point. Freon is commonly used. As it "boils," or changes from a liquid to a gas at -21.7°F, it absorbs energy, in the form of heat, from the warm milk. To repeat the cycle, the freon vapor must then be changed back to a liquid (this is the job of the compressor and condenser), and the heat is transferred through cooling fins and coils to the outside air.

Dairymen should keep the compressor head well ventilated. Dirty fins and/or poor air movement restrict heat transfer in much the same way as an increase in ambient temperature does. They can restrict heat transfer by an amount equivalent to a rise of from 10 to 20°F in ambient temperature. Each rise of 10°F causes about a 10-percent increase in electricity consumption. Therefore, a rise of 10°F in ambient temperature because of poor maintenance of the compressor costs a dairy farmer $24 per year.

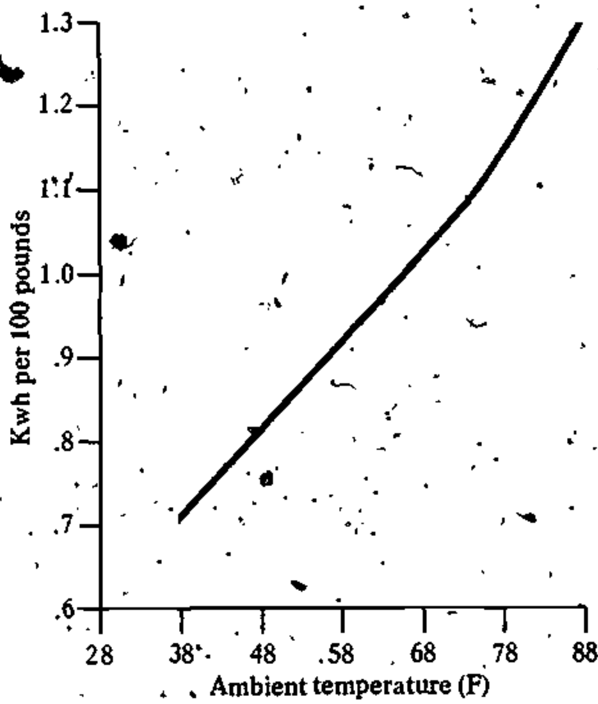

Figure 6. ENERGY CONSUMPTION (KWH) PER 100 POUNDS OF MILK COOLED AT VARIOUS AMBIENT TEMPERATURES

Calculations

1 kWh/100 lb x 12,000 lb/cow x 50 cows x $.04/kWh x 10% = $24.00

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$18.00	$24.00	$30.00	$36.00

EXAMPLE OF CUTTING COSTS BY PROPER MAINTENANCE OF THE MILK COOLER COMPRESSOR. | $20.32 energy savings per year | for a 50-cow dairy with a 12,000-pound herd average.

Maintenance of the refrigeration compressor in a milk cooler is a complicated task. It involves the adding of freon or other volatile substance; the measuring of head, back, and suction pressures plus head temperature; and the use of equipment not readily available. The compressor should be checked yearly because poor adjustment can increase the energy required for cooling as much as 25 percent.

An ammonia compressor system containing 3 percent air reduces the efficiency of the system 17 percent, and can cost $40.32 per year in extra energy.

Table 5--Calculated performances for mixtures of air and ammonia

Air in mixture	Coefficient of performance	Reduction in performance
	Percent	Percent
0	4.40	--
1	3.94	12.7
3	3.66	16.8
5	3.42	22.3

The following calculation assumes a cost of $20 for a service call. Therefore, the net savings is $20.32.

Calculations

12,000 lb milk x 50 cows = 600,000 lb/yr
Electricity to cool 100 lb = 1 kWh
600,000 lb x 1 kWh = 6,000 kWh/yr
6,000 kWh x $.04/kWh = $240.00/yr
Reduced COP with 3 percent air = 16.8 percent
$240.00 x 16.8 percent = $40.32/yr
Service call = $20.00/call

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$10.24	$20.32	$30.40	$40.48

EXAMPLE OF CUTTING COSTS BY USING A PUMP WATER COOLER TO PRECOOL MILK

$30 energy savings per year for a 70-cow dairy

A pump water precooler is one way to reduce the energy required to precool milk. A unit to precool 1,200 pounds of milk per hour from 90° to 70°F can reduce by 40 percent or more the amount of cooling a conventional air-cooled compressor has to do.

Installation of such a precooler costs about $750. Considering depreciation and interest on the equipment, the average annual cost of operation for this type of precooler is about $105.

The table below will give an idea of the practicality of a precooler for different herd sizes and electricity costs. For example, a dairyman with a 70-cow operation and with electric costs of 4 cents per kilowatt-hour, could reduce his electric bill by $134. Deducting the average annual ownership cost of the precooler, a net savings of about $30 is possible.

Calculations

Depreciation: ($750-75)/10-yr life = $67.50/yr
Interest: $750/2 x 8 percent = $30.00/yr
Insurance: $750/2 x 0.8 percent = $3.00/yr
Repairs: $750 x 0.5 percent = $3.75/yr
Ownership costs = $104.35/yr

12,000 lb milk x 70 cows = 840,000 lb/yr
Electricity to cool 100 lb = 1 kWh
(340,000/100) x 1 kWh = 8,400 kWh/yr
8,400 kWh x $0.04/kWh = $336.00/yr
$336 x 40 percent saving = $134.00/yr

Savings at Different Electrical Rates

Herd size	Cents/kWh	3¢	4¢	5¢	6¢
50	Annual savings	$ 70.00	$ 95.00	$120.00	$144.00
60	Annual savings	86.40	115.20	144.00	172.80
70	Annual savings	102.80	135.40	168.00	201.60

The milking operation requires 10 percent of the energy used on the average dairy farm. Because of the constant use of milking equipment, even modest economies will accumulate over the years to produce a meaningful dollar savings.

There are two types of vacuum pumps in common use: the rotary vane and the centrifugal water displacement pump. The latter, with no metal-to-metal contact, has great durability, but it is relatively expensive and not well suited to hard water. The rotary vane pump is used more often.

The number of cubic feet per minute that a vacuum pump will produce depends on the inches of vacuum being held, the elevation of the pump (feet above sea level), the age of the pump, and the revolutions per minute at which the pump is run. The pump is always operating at full capacity whether it is being used at full capacity or not. The excess vacuum generated is handled by "bleeding-in" air through a vacuum controller. A vacuum line should have one controller for each 25 cubic feet per minute produced by the pump.

The motor size on a vacuum pump may depend on the type of pump, the cubic feet per minute required, and the dealer. Some dealers overspecify motor or pump size. If a motor of 3 horsepower is adequate, using a 5-horsepower motor is a waste of energy and money.

ENERGY SAVING TIPS

Major Change

<u>Select</u> a good vacuum pump that meets, but does not exceed, your needs. Keep in mind that systems with two levels of vacuum require much more energy if two vacuum pumps are required.

Routine Maintenance

<u>Maintain</u> the proper oil level to prolong the pump's life and efficiency.

<u>Clean</u> the screen around the air inlet on the vacuum controller to prevent clogging.

<u>Check</u> the belt for tightness and alignment.

Table 6--Average annual energy required per 50-cow herd for specified types of milkers

Type of milker	No. of kilowatt-hours	Cost (dol)
Bucket milker	3,000	120
Bucket milker plus transfer system	4,000	160
Pipeline or parlor	5,500	220
Automatic takeoff (electronic)	7,500	300
Automatic takeoff (two levels of vacuum)	10,000	400

VACUUM PUMPS

EXAMPLE OF CUTTING COSTS BY SOUND VACUUM SYSTEM PLANNING

$228.36 energy savings per year

Consider a situation in which a two-vacuum system has been installed instead of a one-vacuum system.

The extra 3-horsepower vacuum pump will cost $228.36 a year to operate, not to mention the unneeded investment outlay.

Calculations

3-hp motor uses 3.91 kW per h

4 h/day x 365 days/yr = 1,460 h/yr
3.91 kWh x 1,460 h/yr = 5,709 kWh
5,709 kWh x $0.04/kWh = $228.36/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$171.27	$228.36	$285.45	$342.54

VACUUM PUMPS

EXAMPLE OF CUTTING COSTS BY PROPER MAINTENANCE OF VACUUM PUMPS

$4.40 energy savings per year for a 50-cow dairy with a pipeline milker

Dairymen can do several things to keep their vacuum pumps running effectively. Maintaining proper oil levels and keeping belts properly tightened and aligned can increase vacuum pump efficiency by 2 to 5 percent and prolong the life of the pump and motor. This maintenance can save a dairy farmer $4.40 in energy costs alone.

Calculations

Pipeline or parlor = 110 kWh/cow
110 kWh/yr x 50 cows = 5,500 kWh/yr
5,500 kWh/yr x $.04/kWh = $220.00/yr
$220.00 x 2 percent savings = $4.40/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$3.30	$4.40	$5.50	$6.60

EXAMPLE OF CUTTING COSTS BY SOUND VACUUM PUMP PLANNING

$23.36 energy savings per year

A 5-horsepower motor doing the job of a 3-horsepower motor is operating without drawing full power and is wasteful of energy and investment.

A 3-horsepower motor consumes about 3.9 kilowatt-hours per hour of operation. A 5-horsepower motor working at the rate of a 3-horsepower motor consumes about 4.3 kilowatt-hours. This over-specification of motor size would cost a dairyman about $23.36 a year. Over-specification of motor size throughout an operation could cost a dairyman hundreds of dollars in wasted energy.

In purchasing an electric motor, choose the size that will do the job but will not exceed the horsepower needed. This is especially true for constant-load equipment such as a vacuum pump, bulk tank compressor, or feed conveyor. Remember that short periods of overload are not harmful to electric motors, if the motor is not overheated.

Calculations

5-hp motor uses 4.3 kWh (working at 3-hp load)

3-hp motor uses 3.9 kWh

Difference: 4.3 - 3.9 = 0.4 kWh
4 h/day x 365 days = 1,460 h/yr
0.4 kWh x 1,460 h/yr = 584 kWh/yr
584 kWh x $.04/kWh = $23.36/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$17.52	$23.36	$29.20	$35.04

Electric motors are usually efficient in performing a host of labor-saving duties around the farm. But they use the most expensive form of energy.

The individual dollar savings to be realized by the careful planning, purchase and use of electric motors may be small by day, month, or even year; but they can be appreciable over the lifetime of the motors.

Electric motors differ primarily in the amount of starting torque developed and starting current required. The type of motor to use depends on the starting torque requirement of the equipment to be driven. Fans have low starting torque; therefore, split-phase motors are satisfactory. Capacitor start-induction run motors have medium starting torque and are excellent for vacuum pumps and conveyors. Barn cleaners and silo unloaders have high starting torque and require capacitor start-capacitor run, or repulsion-induction motors. Farm equipment manufacturers usually recommend the type and size of electric motor needed.

ENERGY SAVING TIPS

Major Change

Consider using three-phase motors. They cost less to buy, are extremely dependable, and normally operate more efficiently than single-phase (standard electric current) motors.

Routine Maintenance

Check that motors are securely mounted to a smooth, solid foundation, and that pulleys are correctly aligned to avoid excessive wear of belt and bearings.

Maintain proper belt tension. If the belt is too loose, it will slip and cause overheating and excessive belt wear. If it is too tight, it will cause excessive wear of motor bearings. The belt should be snug in the grooves, but not taut.

Clean dust and dirt from motor to ensure proper cooling.

Check bearings for wear. Excessive side or end play may waste current.

Do not overlubricate oil bearings.

Clean starting switch contacts or brushes. Use a very fine sand paper, not emery cloth.

Check to be sure the motor shaft turns freely. Tight or misaligned bearings will cause the motor to overheat and waste energy.

Check belt pulleys to be sure that they are secure on their shafts.

Replace worn belts.

Table 7--Annual energy required per 50-cow herd for specified equipment and activities

Equipment or activity	Kilowatt-hours	Dollar cost
Silo unloader	1,800	72
Feed conveying	800	32
Bunk feeding	600	24
Barn cleaner	500	20
Manure stacker	400	16
Mechanical scraper	6,600	264
Crowd gate	150	6
Roller mill	300	12
Hammer mill	750	30
Well pump	1,600	64

Table 8--Energy requirements of single- and three-phase electric motors with specified horsepower ratings 1/

(kilowatts required per hour of use)

Horsepower rating	Electric motors	
	Single-phase	Three-phase
3/4	1.5	1.0
1	1.8	1.3
1.5	2.3	1.9
2	2.7	2.4
3	3.9	3.5
5	6.4	5.7
7.5	9.2	8.3
10	11.5	10.3
40	-	39.6

1/ For motors with normal torque and speed characteristics at full load.

EXAMPLE OF CUTTING COSTS BY USING THREE-PHASE VERSUS SINGLE-PHASE MOTORS

$35.04 energy savings per year with three-phase current

Three-phase motors cost less to buy and require less energy to operate. A 10-horsepower motor operated for 2 hours a day will cost $35.04 less to run per year on three-phase current than on single-phase current.

Talk to a power supplier about three-phase current. It is not available everywhere, but many power suppliers will install three-phase lines if they feel there is sufficient future demand to pay for the investment.

Calculations

<u>Single phase motor</u>

2 h/day x 365 days/yr = 730 h/yr
730 h x 11.5 kWh = 8,395 kWh/yr
8,395 kWh x $.04/kWh = $335.80/yr

<u>Three phase motor</u>

730 h x 10.3 kWh = 7,519 kWh/yr
7,519 kWh x $.04/kWh = $300.76/yr
Savings ($335.80 - $300.76) = $35.04/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$26.28	$35.04	$43.80	$52.56

EXAMPLE OF CUTTING COSTS BY BUYING A MORE EFFICIENT ELECTRIC MOTOR

$66.00 energy savings in 5 years

The purchase price of a motor is only part of its cost. There is the cost of the energy required for daily operation. Usually the most efficient motor will be the cheapest in the long run.

Assume a farmer can purchase a 3-horsepower single motor that is 3 percent more energy-efficient than a competing brand. How much more could he afford to pay for the more efficient motor? If the motor runs 5 hours per day and he wants the energy savings to pay for the added investment in 5 years, he could pay $66 more.

Calculations

(Efficiency = .746 x hp output/kW input)

<u>Motor A (life = 10 years)</u>

Efficiency: .746 x 3 hp/3.9 kW = 57 percent
5 h/day x 365 days/yr = 1,825 h
1,825 h/yr x 5 years = 9,125 h
3.9 kWh x 9,125 h = 35,679 kWh
35,679 kWh x $.04/kWh = $1,427/5 yrs.

<u>Motor B (life = 10 years)</u>

Efficiency: .746 x 3 hp/3.7 kW = 60 percent
3.73 kW x 9,125 h = 34,036 kWh
34,036 kWh x $.04/kWh = $1,361/5 yrs.
Savings: $1,427 - $1,361 = $66

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$49.00	$66.00	$82.00	$99.00

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EXAMPLE OF CUTTING COSTS BY USING ROLLER MILLS INSTEAD OF HAMMER MILLS

$11.60 energy savings per year for a dairy with a 50-cow herd fed 2 tons of corn per cow

If you are thinking of buying a grain mill, you have a choice to make. Roller mills cost more than hammer mills, but they produce fewer fines. This reason alone has prompted many dairymen to purchase roller mills. But now that energy is more expensive, another fact is emerging: roller mills require less energy than hammer mills.

The energy required to grind feed depends on screen size, moisture content of the grain, and type of grain processed. U.S. No. 2 corn (15 percent moisture) ground in a hammer mill equipped with a 0.25-inch screen and in a roller mill with 0.1-inch clearance is used in this comparison. The hammer mill requires 3.75 horsepower hours per ton of corn processed and the roller mill requires 1.5 horsepower hours per ton. The roller mill would save 290 kilowatt-hours per year, or $11.60, assuming each mill is equipped with an electric motor of 5 horsepower, and a 50-cow herd is being fed 2 tons of corn per cow.

Calculations

Hammer mill

2 tons grain/yr x 50 cows = 100 tons/yr
6.4 kW/5-hp motor = 1.28 kWh
3.75 hp/ton x 1.28 kWh = 4.83 kWh/ton
4.83 kWh/ton x 100 tons = 483 kWh/yr
483 kWh x $.04 = $19.32/yr

Roller mill

1.5 hp/ton x 1.28 kWh = 1.93 kWh/ton
1.93 kWh/ton x 100 tons/yr = 193 kWh/yr
1.93 kWh/yr x $.04/kWh = $7.72/yr

Savings: $19.32 - $7.72 = $11.60/yr

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$8.70	$11.60	$14.50	$17.40

Engines in tractors and pickup trucks are major energy users on any farm. In fact, gasoline and diesel fuel alone account for 65 percent of all energy used on U.S. farms.

Only a thorough work analysis can help rid a dairy operation of fuel waste. We offer no grand scheme here; for each operation is unique. Many common pitfalls exist. Some of these examples may point out fuel wasters that go unnoticed. Most are easy to correct.

When fuel savings are the result of reduced engine operating time, more than just fuel dollars is saved. Nonfuel costs, such as repairs, oil, grease, tires, and the like are reduced. Cutting labor costs is another benefit of reducing operating time.

Simple savings of fuel begin even before you start the tractor, truck, or car.

ENERGY SAVING TIPS

Major Change

Consider buying a diesel tractor or truck. Diesel engines use approximately 25 percent less Btu's per horsepower generated, which means roughly one-fourth fewer gallons of fuel.

Consider electronic ignition and radial tires when buying a new car or pickup. They provide better fuel economy.

Consider all-gear power transmissions. Tests have shown that they are 25 percent more fuel-efficient than hydraulic drives, even at reduced engine speed and when the car or pickup is partly or fully loaded.

Routine Maintenance

Check spark plugs periodically; one fouled spark plug or one stuck valve lifter can cause a loss of 10 to 15 percent of the fuel used.

Maintain proper fuel mixture. Too rich or too poor a mixture wastes fuel.

Have regularly scheduled tuneups; they can save up to 10 percent on fuel.

Keep tires of tractors and other implements properly inflated.

Check for improper lubrication, a loose fan belt, or low oil level; all three increase fuel consumption.

Check tank, lines, fuel pump, and carburetor for leaks.

Keep fuel in the tank, especially in winter, to prevent condensation.

Check fuel usage against the fuel bill.

Don't fill the tank; leave room for expansion.

Plan to reduce the number of miles you drive your pickup and auto.

Use the most energy-efficient tractor or vehicle for the job.

Maintain dispensing records by vehicle and by task performed. This can identify wasteful usage.

Avoid excessive warmups in winter.

Minimize idling. Ten minutes of unnecessary idling a day translates into an additional 30 gallons of fuel you must buy annually.

Don't leave the choke out too long.

Let out the clutch slowly; quick starts waste fuel and are hard on equipment.

Run tractors in the proper gear for the load and condition. Improper shifting and use of the wrong gear can result in a 5-percent fuel loss.

Be sure the thermostat is working properly.

Table 9--Average annual energy required in specified activities of a 50-cow dairy

Activity	No. of gallons gasoline equivalents	Cost (dol)
Feed grinding and mixing	90	45
Manure scraping	180	90
Manure loading	38	19
Manure spreading	138	69
Liquid manure pumping and agitating	180	90
Trench silo unloading with front end loader	120	60
Self unloading wagon	180	90
Mixer wagon	300	150
Pasture work	2 per acre	$1 per acre

EXAMPLE OF CUTTING COSTS BY MATCHING TRACTOR SIZE TO LOAD

$45.00 energy savings per year

Using a larger tractor than is necessary for a job wastes fuel. It takes more horsepower and more fuel for the larger tractor just to move its own weight. Also, engines may have to be operated at 'standard' speed to generate the necessary revolutions per minute for top operation, even if the extra power is not needed. Operating an engine at standard speed wastes fuel.

Spreading manure takes about 100 hours a year. Suppose a 50- or 75-hp tractor would do the job, but you use a 125-hp tractor. It will take 24 units of horsepower to roll the 75-horsepower tractor at 6 miles per hour over a fair surface; the 125-horsepower tractor would use 34 units just to roll its own weight--10 units more than the smaller tractor. Rolling the extra weight and operating the bigger engine will take 1.0 to 1.5 more gallons of fuel per hour, depending upon the engine speeds used. This could mean an extra cost of $40 or more a year.

Calculations

125-hp tractor

3.5 gal/h x 100 h = 350 gal
350 gal x $.45/gal = $158/yr

75-hp tractor

2.5 gal/h x 100 h = 250 gal
250 gal x $.45/gal = $113/yr

Savings: $158 - $113 = $45/yr

50-hp tractor

2.0 gal/h x 100 h = 200 gal
200 gal x $.45/gal = $90

Savings: $158 - $90 = $68/yr

Savings at Different Diesel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$40	$45	$50	$55

EXAMPLE OF CUTTING COSTS BY CORRECTING A GASOLINE TRACTOR THAT MISFIRES — $22.50 energy savings per 100 hours of use

One fouled spark plug can boost fuel usage by 10 to 15 percent. If a 50-hp gasoline tractor is used at full load and full engine speed for an operation that takes 100 hours a year, and the engine is "missing," it could use an extra 45 or more gallons of fuel. This would mean $22.50 to $29.25 or more wasted.

If this tractor is used for other tasks, as undoubtedly it would be, savings from proper maintenance would be much greater.

Calculations

4.5 gal/h x 100 h = 450 gal
450 gal x 10 percent waste = 45 gal
45 gal x $.50/gal = $22.50 per 100 h

Savings at Different Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Savings (per 100 hours of use)	$22.50	$24.75	$27.00	$29.25

EXAMPLE OF CUTTING COSTS BY INSURING PROPER OPERATION OF THE ENGINE THERMOSTAT

$14.00 energy savings per winter season

Be sure the thermostat is functioning properly so that the engine warms up quickly, especially in winter. Fuel consumption decreases by approximately 25 percent when the engine is operating at 180°F instead of 100°F.

If the thermostat on a tractor is stuck during the winter, the tractor may operate at 100°F or less, no matter how long it is used. Assuming the tractor is used 40 hours during the three coldest months of the year, $12.60 would be saved by having a properly functioning thermostat. A new thermostat costs about $3.

Engine operating temperature	Gallons of fuel consumed per hour
100°F	3.5
140°F	3.2
160°F	2.9
180°F	2.8

Calculations

Engine temperature: 100°F

3.5 gal/h x 40 h = 140 gal
140 gal x $.50/gal = $70.00/season

Engine Temperature: 180°F

2.8 gal/h x 40 h = 112 gal
112 gal x $.50/gal = $56.00/season

Savings: $70 - $56.00 = $14.00/season

Savings at Different Diesel Prices

Cents/Gal	40¢	45¢	50¢	55¢
Savings (per winter)	$11.20	$12.60	$14.00	$15.40

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Lighting costs account for 3 to 6 percent of a typical dairy farm's total electric bill.

Review how you use lighting. One 100-watt bulb left on 24 hours a day will cost about $35 a year.

Units used to measure amount of light are: lumens, watts, and foot-candles. The amount of light put out by a bulb is measured in lumens; the amount of electricity used to produce these lumens is measured in watts. Consequently, a measure of efficiency can be "lumens per watt."

A foot-candle is a measure of the amount of light actually falling upon an object (one foot-candle is one lumen per square foot), and is commonly used to indicate the amount of light needed in various work places.

One standard 40-watt fluorescent lamp can put out 3,200 lumens, using 40 watts for the bulb and a few more watts for the ballast (tiny transformer in the lamp fixture). Two standard 100-watt incandescent (Edison) bulbs can put out 3,200 lumens using 200 watts. In this case, the fluorescent lamp would be giving about 60 lumens per watt, while the two incandescent bulbs would be giving only 16 lumens per watt.

Your eye and feelings for the amount of light needed is a good guide, but you may wish to be more accurate. This can be done by buying or borrowing a light meter and referring to the chart below.

Table 10--Average annual energy requirements for specified buildings and outside lighting in a 50-cow dairy

Item	No. of kilowatt-hours	Cost (dol)
Milkhouse	440	18
Parlor	880	36
Freestall barn	2,000	80
Stanchion barn	1,300	52
Outside lighting	440	18
Feed room	220	9
Shop	150	6
Hay storage	220	9

Recommended illumination levels

Building or work activity	Foot-candles
Feeding, inspection, and cleaning	20
Reading charts and records	30
Inspecting udders and teats	50
Washing and sanitizing bulk tank and other dairy utensils	100
Preparing and processing feeds	10
Livestock housing (heat detection, general health)	7
Machinery storage	5
Farm office	70
General inactive areas (to discourage prowlers)	2
Yards and paths	1
Service areas (fuel storage, building entrances)	3

Adopted from Krewatch, "Farm Lighting," FB 2243, p. 10-12.

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The lifespan of a bulb is measured in "average hours of life." This measure is important to consider because it will indicate the frequency with which bulbs must be replaced.

In summary, use the correct amount of light in workspaces, an efficient lamp, and a long-burning bulb. Turn out lights when not in use.

ENERGY SAVING TIPS

Major Change

Consider lighting efficiency in the planning of your new barn, parlor, or other building. Take advantage of sunlight by designing buildings so the longest side faces south. Use transparent fiberglass panels in cold freestall barn roofs. Allow for windows to admit natural light.

Use fluorescent, instead of incandescent, bulbs wherever possible indoors. They provide about 4 times as much light per unit of energy as incandescent bulbs.

Consider mecury vapor, metal halide, or high pressure sodium lamps for large areas outdoors. A mercury vapor lamp provides more than twice as much light per watt as do standard incandescents; a metal halide lamp provides 4 times as much and a high pressure sodium, 5 times as much. The drawback for these lights, however, is that they require 3 to 10 minutes startup time.

Keep in mind that the number of usable foot-candles of a light decreases with the square of the distance between the light source and the workspace. Plan to place lights accordingly to reduce the number of lumens needed.

Routine Maintenance

Replace two bulbs with one that has the same number of lumens. Substitution of one 100-watt incandescent bulb for two 60-watt incandescent bulbs achieves a 16-percent energy saving, and provides approximately the same light.

Clean light fixtures. A clean 25-watt bulb with a clean reflector has the same light intensity as a clean 40-watt bulb with no reflector or a dirty 60-watt bulb with no reflector.

Eliminate unnecessary lights.

Change to a lower wattage, change to more efficient lighting source, or add switches to permit single or small group operation of lamps wherever possible.

Remove unnecessary lamps, especially in rooms where all lights operate off one switch. If you are removing a fluorescent lamp, disconnect the primary side of the ballast. The ballast draws energy even after the removal of the bulb.

Remove lamps in such a way as to keep the work area free of shadows.

Replace fading fluorescent bulbs because their efficiency is decreasing rapidly.

Lighting Chart

Type of lamp	Size by watts	Average output in lumens	Approximate lumens per watt 1/	Average hours of life 2/
Standard incandescent	25	225	9	
	40	480	11	
	60	810	14	750
	100	1,600	16	to
	150	2,500	17	1,000
	200	3,500	18	
	300	5,490	18	
Standard fluorescent	15	660	34	
	20	1,000	40	
	40	3,200	66	18,000
	60	4,080	68	
	75	5,475	78	
Mercury vapor	75	2,800	40	
	100	3,800	40	
	175	7,500	40	24,000
	250	11,600	45	
	400	21,000	50	
	700	39,000	50	
Metal halide	175	12,000	65	
	400	34,000	80	18,000
	1,000	95,000	90	
High pressure sodium	250	25,000	80	
	400	47,000	160	20,000
	1,000	130,000	110	

1/ Includes the power requirement for the ballast when appropriate.
2/ These hours vary, and you should check the specifications on the package. "Long-life" incandescent bulbs are available in the range of 3,500 hours, but they deliver 10-15 percent fewer lumens per watt.

EXAMPLE OF CUTTING COSTS BY CAREFUL ATTENTION TO LIGHTING USE

$192.00 energy savings per year

Lights may not consume large amounts of electricity when used properly, but improper use and neglect can cost a substantial amount. Turning off lights when they are no longer needed saves energy and dollars.

One dairy farmer reports saving 400 kilowatt-hours on his electrical bill when his hired man quit and he hired another. Apparently, the first man had a hard time remembering to turn off lights. The decrease of 400 kilowatt-hours may seem an unduly large amount, but when broken down to the number of 100-watt bulbs burned continuously, it seems possible. In 1 month, six 100-watt bulbs used continuously would consume 432 kilowatt hours at a cost of $17.28 per month, or $210.24 per year.

The farmer's savings for a year amounted to $192.

Calculations

<u>Six 100-watt bulbs burning continuously</u>

100 watts x 6 bulbs = 600 watts
600 watts x 24 h/day = 14,400 watt h/day
14.4 kWh/day x 30 days = 432 kWh/month
14.4 kWh/day x 365 days = 5,256 kWh/yr
5,256 kWh x $.04/kWh = $210.24/yr

<u>Save 400 kWh/month</u>

400 kWh/month x 12 months = 4,800 kWh/yr
4,800 kWh x $.04/kWh = $192/yr

<u>Savings at Different Electrical Rates</u>

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$144.00	$192.00	$240.00	$288.00

EXAMPLE OF CUTTING COSTS BY CHANGING FROM INCANDESCENT TO FLUORESCENT BULBS

$39.84 energy savings per year

Six 100-watt incandescent bulbs, used in a stanchion barn 6 hours per day, put out approximately 9,600 lumens of light. Three 40-watt fluorescent bulbs did the same job (9,600 lumens). The cost of changing from incandescent to fluorescent lamps is about $30 to $35. The savings from that point on could be $39.84 per year.

Calculations

Six 100-watt incandescent bulbs

100 watts x 6 bulbs = 600 watts
600 watts x 6 h/day = 3,600 watt h/day
3.6 kWh x 365 days = 1,314 kWh/yr
1,314 kWh x $.04/kWh = $52.56/yr

Three 40-watt fluorescent bulbs

Average lumens per watt = 66
3,200 lumens ÷ lumens per watt = 48.5 watts/lamp
48.5 watts (bulb and ballast) x 3 = 145.5 watts
145.5 watts x 6 h/day = 873 watt h/day
0.873 kWh x 365 days = 318 kWh
318 kWh x $.04/kWh = $12.72

Savings: $52.56 - $12.72 = $39.84

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$29.88	$39.84	$49.80	$59.76

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The purpose of keeping records of physical units of energy is twofold. First, with what looks like continually increasing costs of energy, financial records alone are of little value in evaluating energy savings since total expenditures will probably continue to rise. Second, records in terms of kilowatts and gallons will indicate specific amounts of energy saved.

To begin keeping records, subtract the amount of electricity used in the house from the amount used in the dairy, if both are on one meter. The following tables should help you estimate the number of kilowatt hours you use in your residence. The amount of electrical energy used in a typical home for lighting and appliances is 400-600 kilowatt-hours per month. This includes electrical energy used for cooking but not an electric hot water heater. The amount of electricity required for the water heater varies among families. (One 10-minute shower requires about 7 kilowatt-hours of electricity to heat the water used.) Heating and air conditioning are not included in the above figure. (The fan on an oil or gas furnace requires approximately 0.6 kilowatt-hour of electricity per gallon of fuel burned.) If your house is heated electrically, you already know about increased electric bills.

The following recordkeeping charts should help you to determine your electricity and fuel use. Identify those parts of your operation where you can save the most energy and money. Compare your present practices (hours of use) with revised practices. Use chart I on energy use to calculate the amount of electricity you presently use to care for your herd. Deduct the amount your household consumes and enter the remaining montly kilowatt-hour usage on the worksheet.

Record hours of operation of major types of equipment on chart II. The preceding sections list types of equipment and typical amounts of energy used. Combine the information on chart II with information from charts III and IV to help determine the energy used in major dairy related tasks.

Chart III on energy use is for estimating kilowatt hours used in performing chores. Use it as follows:

(1) Enter the horsepower of the motor for each piece of electrical equipment.

(2) Select the correct conversion factor for the size motor from the table on electric motors in chapter 6. (For example, 6.440 kilowatts are required per hour of use for a 5-horsepower motor.)

Table 11--Fuel consumption of common tractors and vehicles

Vehicle	Size of vehicle	Gasoline per hour	Diesel per hour
		(gal)	(gal)
Tractor	25 hp	1.7	--
	40 hp	2.7	1.9
	60 hp	4.1	2.9
	90 hp	6.1	4.3
Truck	1/2-ton	1.0	--
	1-1/2 ton	1.8	--

Table 12--Electric current and fuels required to heat 100 gallons of water

Item	Unit	Quantity
Electricity	kW	29
LP gas	gal	1.7
#2 fuel oil	gal	1.2

Energy Use--Chart I
(kilowatt hours used per cow)

Month	Base year			Comparison year			
	Kilowatt hours 1/	Number of cows 2/	Usage per cow 3/	Kilowatt hours 1/	Number of cows 2/	Usage per cow	Percentage change
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							
Total							

1/ Enter number of kilowatt hours on your bill minus monthly house use. Be consistent in the amount you deduct. Enter the hours of use per unit of time. (For example, 40 hours per month.)

2/ Include both dry and lactating cows.

3/ Multiply kilowatt hours by number of cows to get your usage per unit. (For example, 6.440 x 40 = 257.6 kilowatt hours of usage per month.)

If you save just one kilowatt hour per day, you will save $14.60 per year (at 4¢ per kWh). You can save energy and money by knowing how and where you use the energy you purchase.

Energy Use--Chart II
(hours of use by farm equipment)

Type of equipment	Average hours used per month 1/												Total for year 2/
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

1/ For example, number of hours per month that your bulk tank compressor runs.

2/ Enter in the "use per unit of time" column of Chart III.

Energy Use--Chart III
(electric motors)

Type of equipment	Horsepower of motor	Conversion factor 1/	Use per unit of time	kWh per unit of time

1/ Conversion factors are in table on electric motors

Energy Use--Chart IV
(tractors and trucks)

Type of equipment	Size	Conversion factor 1/	Use per unit of time	Fuel used per unit of time

1/ Conversion factors are in fuel consumption table.

Chart IV on energy use is for estimating gasoline or diesel fuel usage. Use it like chart III. It could be used in conjunction with your records on refueling. The number of gallons of fuel used by each vehicle and each task is valuable information to have for determining which ones are more efficient in terms of horsepower produced and/work done.

Since farmers may have their household electricity on the same meter as the electricity used in farming, we are including the following table so the reader may estimate the electric power used in the home.

Appendix table 1--Monthly Energy Requirements of Electric Household Appliances

Appliance	Estimated kWh consumed monthly 1/
For food preparation:	
Broiler	8
Coffeemaker	9
Deep fryer	7
Dishwasher	30
Frying pan.	20
Hot plate	8
Oven, microwave only	20
Range with oven	100
Roaster	20
For food preservation:	
Freezer (15 ft^3)	100
Freezer (frostless 15 ft^3)	150
Refrigerator (12 ft^3)	60
Refrigerator (frostless 12 ft^3)	100
Refrigerator/Freezer (14 ft^3)	95
Refrigerator/Freezer (frostless 14 ft^3)	150
For laundry:	
Clothes dryer	80
Iron (hand)	10
Washing machine (automatic)	8
Washing machine (nonautomatic)	6
Water heater	400

(continued)

See footnotes at end of tabulation

Appliance	Estimated kWh consumed monthly 1/
For comfort conditioning:	
Air conditioner (room)	70 2/
Blanket	10
Dehumidifier	30
Fan (attic)	20
Fan (window)	10
Heater (portable)	15
Humidifier	10
For home entertainment:	
Radio	7
Radio/record player	9
Television --	
Black & white tube type	30
Black & white solid state	10
Color tube type	55
Color solid state	40

1/ When using these figures for projections, such factors as the size of the specific appliance, the geographic area, and individual usage should be considered.

2/ Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit. You can approximate the energy used in air conditioning by multiplying tons of capacity (12,000 Btu's = 1 ton) times hours used. This will approximate the kilowatt-hours of electricity consumed.

Source: Electric Energy Association.

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BTU ACCOUNTING

The producer can convert the quantities of different types of fuel used on his farm to a common measure, the Btu of energy used with the aid of the conversion factors in the tabulation below. The producer may find this measure useful when comparing total energy use from year to year or month to month or when comparing alternative equipment or practices in terms of energy use where more than one type of fuel is involved. For example, if one used 4,000 gallons of propane, 500 gallons of regular gasoline, and 25,000 kilowatt hours of electricity last year, the total energy use in Btu would be 515.3 million Btu. The calculations follow:

4,000 gallons propane x 92,000 Btu/gal	= 368,000,000
500 gallons reg. gasoline x 124,000 Btu/gal	= 62,000,000
25,000 kWh x 3,412 Btu/kWh	= 85,300,000
Total Btu	515,300,000

Btu Conversion Factors

Gasoline (regular)	6.12 lb/gal	124,000 Btu/gal
Diesel fuel (no. 2)	7.07 lb/gal	140,000 Btu/gal
Propane	4.25 lb/gal	92,000 Btu/gal
Natural gas		1,067.5 Btu/gal
Natural gas		100,000 Btu/therm
Fuel oil (no. 2)	7.2 lb/gal	138,500 Btu/gal
Coal (anthracite)		25,894,000 Btu/ton
Coal (high-volatile bituminous)		23,734,000 Btu/ton
Coal (lignite)		13,894,000 Btu/ton
Electricity		3,412 Btu/kWh

Sources: Environmental Engineering Analysis and Practice, Burgess H. Jennings, International Textbook Company, Scranton, PA, 1970 and Tractors and Their Power Units, by Barger, Liljedahl, Carleton and McKibbon, 2nd ed., Wiley and Sons, N.Y., 1963.