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DOCUMENT RESUME

ED 168 896 SE 027 546

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TITLE	A Guide to Energy Savings - For the Livestock Producer.
INSTITUTION	Department of Agriculture, Washington, D.C.; Federal Energy Administration, Washington, D.C.
PUB DATE	Jun 77
NOTE	98p.; For related documents, see SE 027 544-549
AVAILABLE FROM	Office of Communication, Publications Division, U. S. Dept. of Agriculture, Washington, D.C. 20250 (single copies free while supply lasts)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	*Agricultural Production; *Agriculture; Conservation Education; Energy; *Energy Conservation; *Farmers; Instructional Materials; *Livestock; Postsecondary Education

ABSTRACT

This booklet gives a brief overview of energy use in livestock production and gives examples of cutting costs of field equipment use, grinding and preparing feed, managing range and herd, ventilating and heating, lighting, drying grain, and irrigating with sprinklers. Recordkeeping and estimating energy use is also discussed. (BB)

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

This guidebook was prepared by Roy N. Van Arsdall, Meat Animals Program Area, Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. H. C. Gilliam, C. C. Boykin, C. K. Gee, J. E. Trierweiler, and A. J. Baker assisted in the preparation. It was prepared under the supervision of George B. Rogers, Energy Coordinator, Commodity Economics Division, and 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 Poultry Producer, A Guide to Energy Savings for the Vegetable Producer, A Guide to Energy Savings for the Orchard Grower, A Guide to Energy Savings for the Field Crops Producer, and A Guide to Energy Savings for the Dairy Farmer.

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ACKNOWLEDGMENTS

This guide has been reviewed by the organizations and individuals listed below.*

Organizations: American Farm Bureau Federation, American National Cattlemen's Association, American Sheep Producers Council, Inc., National Council of Farmer Cooperatives, National Grange, National Livestock Feeders Association, and the National Pork Producers Council.

Individuals: Joe L. Koon, Auburn University; Charlie G. Coble and Wayne Le Pori, Texas A & M University; John W. Glover, R. E. Sneed, and L. Bynum Driggers, North Carolina State University; H. B. Altman, R. G. Yech, Hoyle Puckett, O. U. Bay, and Dixon Hubbard, 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. Data and assistance from Professors J. A. Weber and D. A. Hunt of the University of Illinois are also greatly appreciated.

* Listing does not imply official action to endorse the report or complete agreement with its contents.

JUNE 1977

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INTRODUCTION

The Nation's 2½ million farms consume 6.3 billion gallons of gasoline and diesel fuel, some 167 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.

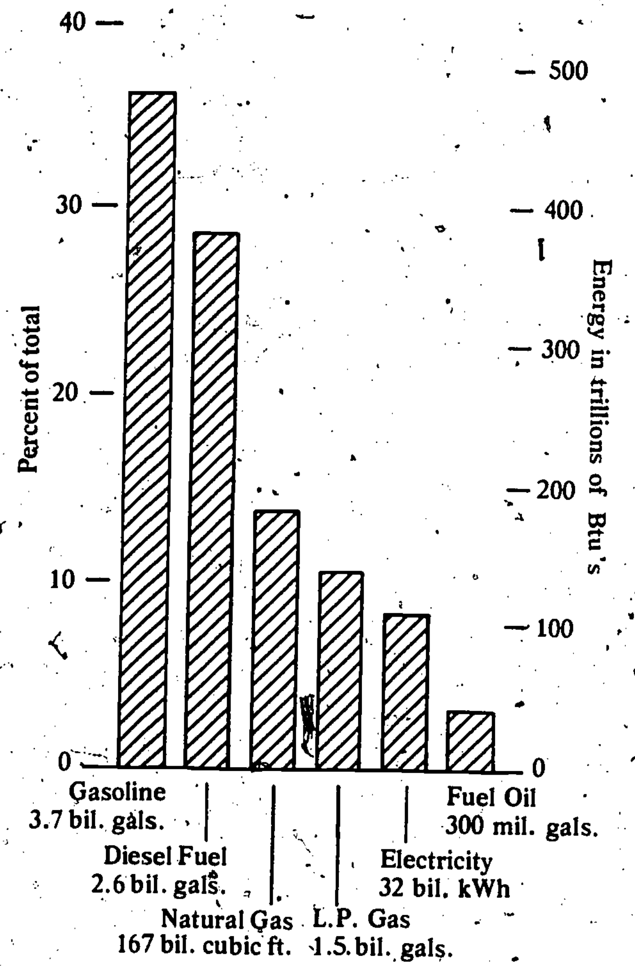

Figure 1. ENERGY USED IN AGRICULTURE (1974)

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.

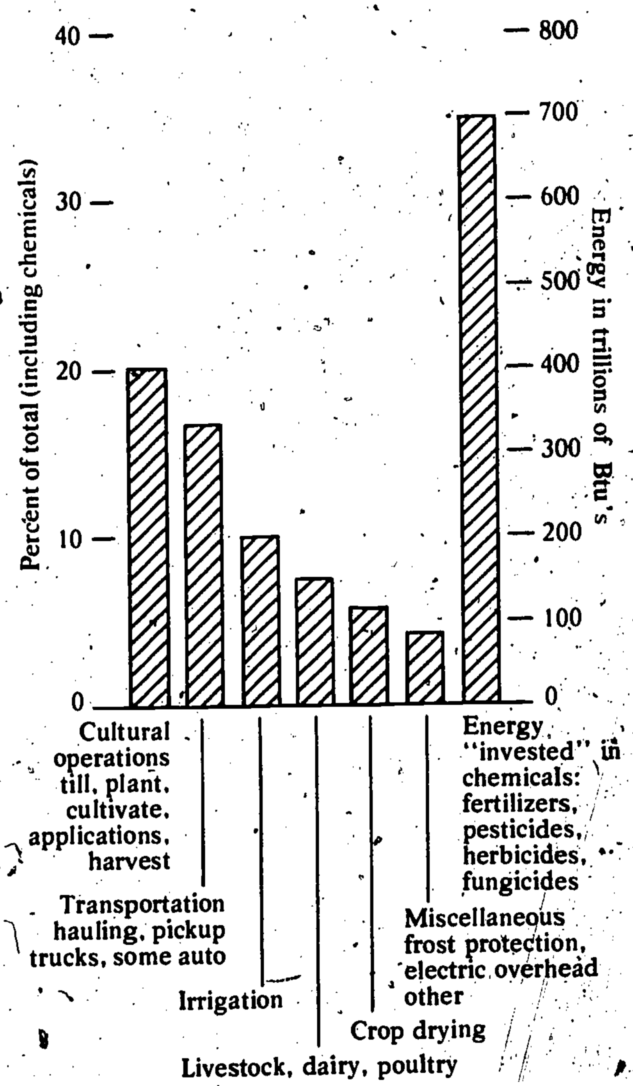

Figure 2. ENERGY USED IN AGRICULTURE, PLUS FERTILIZER AND CHEMICALS, (1974)

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

Commodity	Inventory 2/ (head)	Gasoline (gal)	Diesel (gal)	Fuel oil (gal)	LP gas (gal)	Natural gas (ft^3)	Electricity (kWh)	Invested energy 3/ (Btu)	Total energy 4/ (Btu)	Energy per head (Btu)
	Thousands	Thousands				Millions		Billions		Thousands
Beef:										
Cows & calves	44,537	314,160	175,500		11,317		346		66,096	1,484
Feedlots	23,936	76,675	86,362			10	1,143		25,585	1,069
Hogs	[illegible]	115,074	79,777		50,188		2,001		37,149	432
Sheep & lambs	14,52[illegible]	21,802	6,546				18		3,703	255
Total meat animals	168,931	527,711	348,185		61,505	10	3,508		132,533	785
Other livestock		289,654	4,231	8,817	271,380	4,615	6,520		91,758	
Total livestock		817,365	352,416	8,817	332,885	4,625	10,028		224,291	
Total crops 2/	340,596 5/	2,881,276	2,286,539	295,112	1,148,657	159,500	22,060	716,452	1,789,930	5,255 6/
Total agriculture		3,698,641	2,638,955	303,929	1,481,542	164,125	32,088	716,452	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/ Invested energy includes the energy required to manufacture fertilizers and pesticides (including carrier solution).

4/ Other livestock energy use includes some energy derived from coal.

5/ Thousand acres.

6/ 1,000 Btu per acre.

Livestock production activities consumed about 133 trillion British thermal units in 1974--beef cattle about 92 trillion, hogs about 37 trillion, and sheep about 4 trillion British thermal units. (One British thermal unit is the heat required to raise the temperature of 1 pound of water from 62°F. to 63°F.) This energy was used chiefly for lighting, feed processing and distribution, providing water, assembly or handling livestock, space heating, ventilation, water heating, general farm travel, and farm automobile use.

Some types of livestock use more energy for a particular operation than others (table 2).

The relative importance of the various forms of energy used also varies by kind of livestock (table 3). Producers with stocker cattle, sheep, and extensive cow-calf enterprises rely heavily on gasoline for trucks used in feed distribution and checking of the animals. Diesel fuel for tractors is of moderate importance in most operations. It is used chiefly for feed distribution and general chore work with the more extensive enterprises and for feed processing and distribution and manure handling with the more intensive enterprises. Heavy use is made of electricity and LP or natural gas only in intensive enterprises such as hog production and cattle feeding, especially where heat and ventilation must be supplied.

Table 2--Percentage of livestock energy use, by operation, 1974 1/

Operation	Beef cow-calf operation	Beef stock operation	Beef feedlot	Sheep and lambs	Hogs farrowed to finish	Hogs feeder pig production	Hogs feedlot
				Percent			
Light	0.53	0.12	5.46	0.35	0.91	0.67	0.64
Feed processing and distribution	46.00	23.20	39.86	20.72	11.09	33.78	22.43
Waste handling	1.71	1.45	8.97	2.40	7.77	12.26	22.08
Water supply	1.40	0.34	16.78	0.19	6.61	6.63	12.10
Assembly-handling	1.91	4.69	---	11.53	0.03	0.42	0.13
Space heat	0.24	---	0.04	.81	16.19	7.88	---
Ventilation	---	---	---	---	8.67	4.88	2.75
Water heating	---	---	---	---	0.05	0.42	0.59
General farm travel	25.47	45.74	18.89	57.65	30.65	18.93	24.86
Farm automobiles	13.02	23.38	9.65	6.35	16.92	10.46	13.73
Other	9.72	1.11	0.52	---	0.94	3.67	0.69
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1/ Percentages based on all fuels and electricity converted into Btu equivalents.

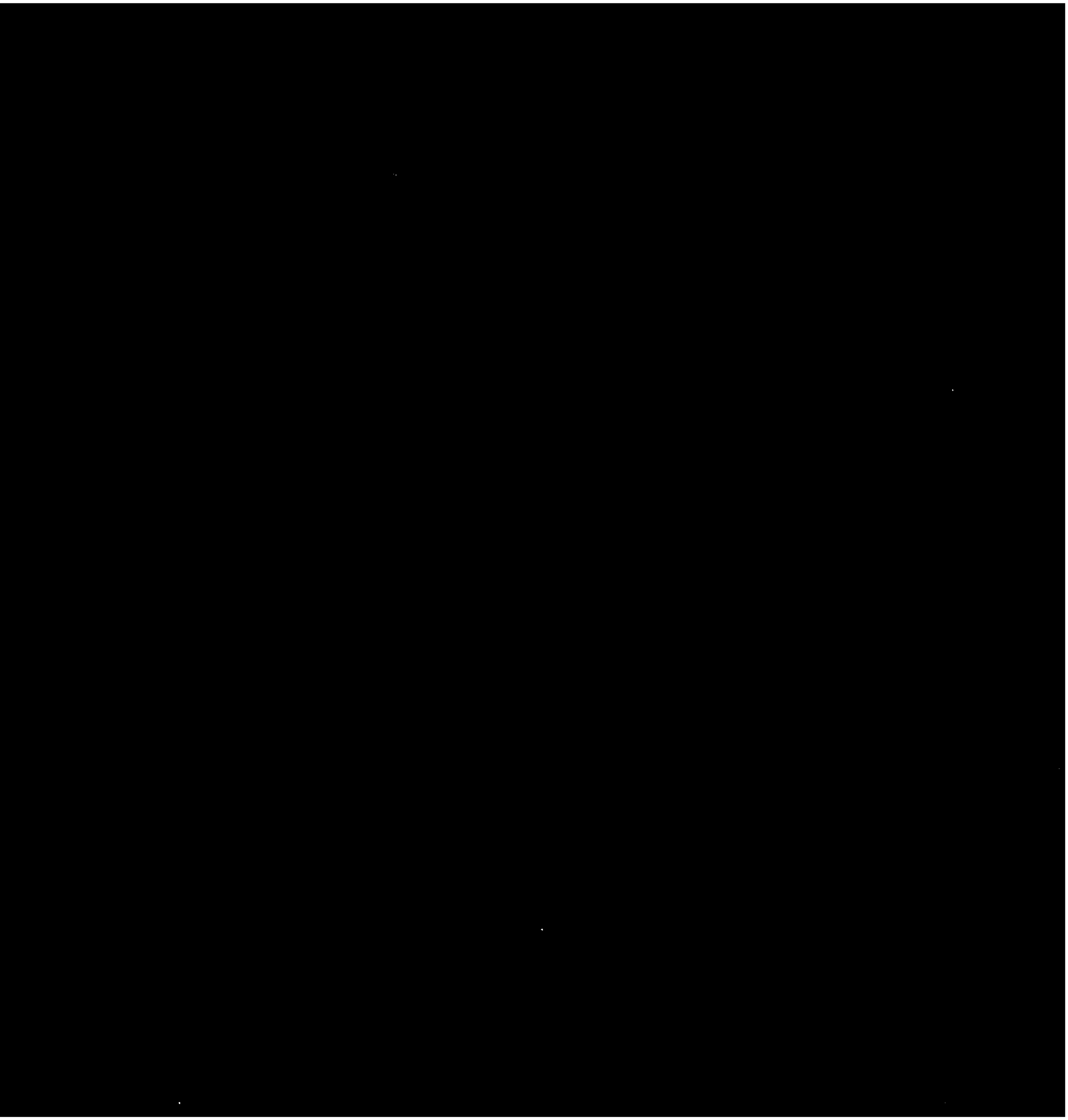

Table 3--Percentage of Btu from various energy sources, by type of livestock enterprise

Energy sources	Beef cow-calf operation	Beef stock operation	Beef feedlot	Sheep and lambs	Hogs farrowed to finish	Hogs feeder pig production	Hogs feedlot
				Percent			
Gasoline	45.05	94.95	37.45	73.61	38.11	47.79	37.96
Diesel	50.45	4.33	47.26	24.74	28.20	31.07	44.84
LP gas	2.19	0.24	---	---	14.87	6.66	---
Natural gas	---	---	0.04	---	---	---	---
Electricity	2.31	0.48	15.25	1.65	18.82	14.48	17.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Energy-saving ideas for typical livestock operations are offered in this guide. Farm management specialists estimate that livestock producers may save 10 to 20 percent of the energy used now by working at energy conservation.

SELECTING AND USING FIELD EQUIPMENT

The saving of fuel begins even before you start your tractor, truck, or car. Consider the following tips:

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

2. Don't let the tank stand empty, especially in winter; condensation may form and the watered gas may keep the engine from running properly.

3. Lock the fuel pump when it is unattended.

4. Check the usage against the bill.

5. Don't overfill; leave room for expansion.

6. Maintain dispensing records by vehicle and by task performed to help to identify excessive usage.

7. Check storage tank for leaks, check valve packings, and check for seepage at discharge nozzle.

8. Shade or paint the storage tank white to reduce evaporation.

OPERATION

1. Avoid excessive warmups in winter. Idling can consume 15 to 20 percent of the fuel used.

2. Always turn off the tractor engine rather than let it idle. If you let the tractor engine idle for 10 minutes a day, that comes to 61 hours a year. Sixty-one hours of idling of a 75-horsepower diesel tractor will use about 30 gallons of fuel.

3. Don't leave the choke out.

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

5. 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 greater fuel use.

6. Be sure that the thermostat works properly.

MAINTENANCE

1. Check the ignition. One fouled spark plug or one stuck valve lifter can cause a loss of 10 to 15 percent of the fuel used in a vehicle.

2. Check carburetion. Too rich a mixture of fuel wastes it, and too lean a mixture prompts fuel-consuming corrective measures.

3. Regularly schedule tuneups; a 10-percent savings in fuel usage may be realized.

4. Keep the tractor tires and those on other implements properly inflated.

5. Lubricate properly. Dry bearings will increase fuel consumption and accelerate wear.

PLANNING

If you are planning to purchase a new tractor or truck, consider the purchase of a diesel unit. Diesel units can reduce fuel usage by 25 percent or more. If you are planning the purchase of a new car or pickup, consider radial tires. They provide 15 to 20 percent better fuel economy.

Tractors with all gear power transmissions are 25 percent more efficient on fuel than hydraulic drives even at reduced engine speed and part load as well as at full load according to University of Nebraska tests. This consideration partly offsets the greater convenience of a hydrostatic transmission.

Planning and sometimes redesign of facilities can often save fuel. For example, it saves time to use fence line bunks for feeding rather than having bunks in the feedlot. Even more important, the tractor hauling the feed wagon will not use as much power on a good surface as it would inside the feedlot and will not idle while gates are opened and closed.

EXAMPLE OF ENERGY SAVINGS THROUGH MAINTAINING PROPER ENGINE TEMPERATURE	$15.40 in energy saved in 40 hours	by replacing an inoperative thermostat

Be sure the thermostat is functioning properly so the engine warms up quickly, especially in winter. Fuel consumption increases by approximately 25 percent when the engine is operating at 100°F instead of 180°F. 1/

If the thermostat on your tractor is stuck open during the winter, your tractor may operate at 100°F or less no matter how long you use it. Assuming the tractor is used 40 hours during the 3 coldest months of the year, you could save 28 gallons of gasoline by having a properly functioning thermostat.

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

1/ Berge, D. I., "Tips on Energy Savings for Wisconsin Farmers," Newsletter of the Dept. of Agr. Eng., Univ. of Wisconsin, Madison, Dec. 1973, p. 3.

Calculations

Faulty thermostat

.7 gal/hr x 40 hr = 28 gal
28 gal x $.55/gal = $15.40 savings on energy

Savings at Various Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Annual savings	$14.00	$15.40	$16.80	$18.20

Nonenergy Costs: Installation of a new thermostat could cost $15 to $30. Thus, costs just about offset the value of fuel saved. Individually, use of a proper thermostat will not affect income much if any. In total, it could mean several million gallons difference in fuel use.

EXAMPLE OF ENERGY SAVINGS THROUGH MATCHING TRACTOR SIZE TO LOAD

Using a larger tractor than necessary for a job wastes fuel. It takes more horsepower and more fuel just for the larger tractor to move its own weight over a field. Also, engines may have to be operated at "standard" speed to generate the necessary revolutions per minute for power take off operations even if the extra power is not needed. That wastes fuel.

Suppose that you have a job such as spreading manure. It takes 100 hours a year. A 75-horsepower tractor would do the job, but you use a 125-horsepower tractor available from the complement of field crop machinery. It will take 24 horsepower to roll the 75-horsepower tractor at 6 miles per hour over a fair surface; the 125-horsepower tractor will use 34 horsepower just to roll its own weight--10 horsepower 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. This could mean $50 or more a year.

$56.25 in energy saved per year by using a 75-horsepower rather than 125-horsepower tractor for 100 hours

<u>Calculations</u>

100 hr x average 1.25 gal/hr = 125 gal
125 gal x 45¢/gal = $56.25

<u>Savings at Various Diesel Fuel Prices</u>

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$50.00	$56.25	$62.50	$68.75

EXAMPLE OF ENERGY SAVINGS THROUGH CHOICE OF TRACTOR FUELS

Every farmer and rancher should be familiar with the efficiency of diesel and gasoline tractor fuels. Most tractors now manufactured, even many of the smaller-sized units, use diesel fuel, but a rather wide selection of gasoline-powered tractors are available.

A rule of thumb is that given the horsepower (hp) and running time, a diesel tractor will use 0.7 as many gallons of fuel as a gasoline tractor. Not only are there differences in fuel requirements for a given power output, but there are also differences in the cost and relative availability of the different kinds of fuels. All advantages point toward the diesel-powered tractors.

You may have a mixture of tractors with respect to kind of fuel. It may be more economical to continue using your present tractors for awhile, but, when it is time to trade for newer machines, you should give strong consideration to moving toward diesel for all tractors.

A 75-horsepower diesel tractor which is used 500 hours a year and operates at an average output of 50 horsepower will use about 1,925 gallons of diesel fuel per year. The same size gasoline tractor operating under the same conditions will use about 2,675 gallons of fuel annually. The difference in total fuel cost on an annual basis can be substantial depending upon the price of gasoline and diesel fuel. If you now pay 45 cents a gallon for diesel fuel, and 55 cents for gasoline, the yearly fuel bill would be $866 for diesel or $1,471 for gasoline.

$605.00 in energy saved per year using a 75-horsepower diesel versus	a 75-horsepower gasoline tractor operating 500 hours at 50-horsepower output

Calculations

75-hp gasoline tractor: Average 50 hp output at full engine speed.
500 hr x 5.35 gal/hr = 2,675 gal of gasoline

75-hp diesel tractor: Average 50 hp output at full engine speed
500 hr x 3.85 gal/hr = 1,925 gal of diesel

Fuel Costs at Various Prices per Gallon

Diesel fuel

Cents/gal	40¢	45¢	50¢	55¢
Fuel cost for 500 hours (1,925 gal)	$770	$866.25	$962.50	$1,058.75

Gasoline

Cents/gal	50¢	55¢	60¢	65¢
Fuel cost for 500 hours (2,675 gal)	$1,337.50	$1,471.25	$1,605	$1,738.75

Nonenergy Costs: Manufacturers do not offer many new gasoline tractors. Most are diesel. Where both are available in a given size, the diesel unit will usually be higher priced. You will have to figure whether the fuel economies of the diesel tractor offset its higher annual overhead cost. The gasoline tractor will only be the least costly if it is used little.

EXAMPLE OF ENERGY SAVINGS THROUGH BETTER MANAGEMENT OF FARM GATES

On the average, a properly operating gate takes at least a minute for someone to go through it with a tractor. One must stop, get off the tractor, walk to the gate, unlatch it, push it open, return to the tractor, get on it, drive through the gate, get off the tractor, walk back to the gate, close and latch it, walk back to the tractor and mount it.

If a farmer goes and returns through one gate every day, it will cost him about 12 hours a year, hours that the tractor engine will be running.

Suppose a livestock producer uses two properly operating gates and one poor gate each day throughout a year. The poor gate will take 24 hours; the two good gates will take another 24 hours. That is 48 hours total or more than the time in a regular workweek. The tractor engine is running all this time at idling speed, perhaps a little faster. Fuel consumption for an average 75-horsepower diesel tractor will be at least 0.5 gallons per hour or 24 gallons of fuel per year spent just in opening the gate.

Calculations

<u>Present routine</u>: Two good gates and one poor gate through and back daily at 1 minute per opening for good gates; 2 minutes for the poor gate.

4 trips through per day x 1 minute per trip x 365 days = 1,460 minutes

1,460 minutes ÷ 60 minutes per hour = 24.3 hours on good gates

2 trips through per day x 2 minutes per trip x 365 days = 1,460 minutes

1,460 minutes ÷ 60 minutes per hour = 24.3 hours on poor gate

Time per year going through gates = 48.6 hours

48.6 hours per year x 0.5 gallon per hour = 24 gallons a year

<u>Improved routine</u>: Adjust travel route and facilities to eliminate one gate, replace one gate with a stock-guard crossing, and put one remaining gate in working order. One gate left to go through and back daily at 1 minute per opening.

2 trips per day x 1 minute per trip x 365 days = 730 minutes

730 minutes ÷ 60 minutes per hour = 12.2 hours

12.2 hours per year x 0.5 gallons per hour = 6 gallons a year

18 gallons saved plus <u>nearly a week of labor time</u>.

<u>Dollars Saved at Various Prices for Diesel Fuel</u>

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$7.20	$8.10	$9.00	$9.90

Nonenergy Costs: The producer may have to add a regular gate at the stock-guard crossing.

$8.10 in energy saved per year for the enterprise

GRINDING AND PREPARING FEED

Processing grain by grinding, rolling, flaking, and cooking and mixing feed ingredients into a complete ration is basic to livestock production. It requires substantial amounts of electrical energy. To conserve here, select the method of processing carefully. Perhaps free choice feeding is most economical.

Operation

Follow the manufacturers' operating recommendations on grinders, mixers, and other feeding equipment. Make sure the motor is securely mounted when using electrically powered equipment. Poor mounting can cause excessive bearing wear and loss of power.

The motor pulley and equipment pulley must be correctly aligned on belt-driven equipment to avoid excess wear of belt and bearings. Proper belt tension is essential on belt-driven equipment. The belt should be "snug" in the grooves, but not "taut."

Maintenance

Grinders and mixers should be kept lubricated and the bearings checked for wear. Dry and worn bearings and dull hammers on hammer mills will cause operating inefficiencies and burn more energy.

Electric motors require little maintenance, but a few things should be done at least once a year.

1. Clean motor to ensure proper cooling.

2. Check bearings for wear. Excessive side- or end-play may cause excessive current usage.

3. Do not overlubricate bearings. Too much oil is just as bad as too little.

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

5. Check to be sure the motor shaft runs freely. A tight or misaligned bearing will cause the motor to overheat and waste energy.

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

7. Check belt tension and replace badly worn belts.

Planning

Examine whether grinding or another method of processing feed is best. Research suggests that dry shelled corn is just as efficient a feed for beef cattle as ground shelled corn. Also commercial supplement for hogs can be purchased that can be fed free choice to supplement shelled corn.

If one plans to use large electric motors, he might consider three-phase motors. These are more economical but require three-phase electrical service.

When expanding or purchasing new equipment, a farmer should talk to his power supplier about how to obtain three-phase current for part of the farm's operation.

All costs, including the amount of energy required to run a piece of equipment, should figure into your purchasing decision.

Table 4--Kilowatts used per hour of operation by electric motors of various sizes for single and three-phase electric service 1/ 2/

Horsepower rating of electric motor	Kilowatts required per hour of use	
	Single-phase service	Three-phase service 3/
1/4	.667	---
1/3	.828	---
1/2	1.127	.762
3/4	1.587	1.067
1	1.840	1.334
1-1/2	2.300	1.905
2	2.720	2.476
3	3.909	3.531
5	6.440	5.715
7-1/2	9.203	8.376
10	11.500	10.290
40	---	39.640

1/ Adapted from Farrall, Arthur W., Engineering for Dairy and Food Products, Kreiger Publishing Co., Inc., Huntington, N.Y., 1973, p. 53. Theoretically, the kilowatts required per hour of use should be less than shown--approximately 1 hp per kWh for most sizes. When the loads are uniformly applied to motors close to the optium load for which the motor was designed, better efficiency can be expected than is shown in this table.

2/ For motors with normal torque and speed characteristics. These are full load rating that ignores the power factor; (which lowers the kilowatts required per hour of use) plus startup current demand and other factors which increase the kilowatts demanded. Motors built for especially low speeds or high torque may require more current. If a specific motor is of concern, check the nameplate data.

3/ Where three-phase service is available.

EXAMPLE OF ENERGY SAVINGS BY NOT PROCESSING CORN FOR BEEF CATTLE FEEDING

$43.28 to $156.24 in energy saved per year by feeding	20,000 bu of whole rather than ground shelled corn to beef cattle

Recent research shows that grinding dry shelled corn does not increase its efficiency as a cattle feed over whole grain.

If you do grind corn for cattle, you can use one of two types of mills, hammer or roller. Roller mills cost more but they produce less fines, an incentive to producers to buy them. Roller mills also require less energy than hammer mills.

The energy required per ton of feed ground varies with the screen size, moisture content of the grain, and type of grain processed. Although corn does not have to be ground for feeding beef cattle, grinding corn is used here to demonstrate power differences between a tractor-powered hammer mill, an electric hammer mill, and an electric roller mill.

Grinding dry shelled corn at a high rate with a tractor-powered hammer mill requires a large tractor and lots of fuel. Coarse grinding of 20,000 bushels of corn a year, which is about the requirement of 350 steer calves fed to slaughter weight, requires about 350 gallons of diesel fuel. Grinding the corn so it would pass through a fine screen would take twice the time and fuel.

An electric-powered hammer mill equipped with a 5-horsepower motor requires 3.75 horsepower hours per ton of corn processed. To grind the 20,000 bushels of corn would require 2,705 kWh of electricity per year. A roller mill with a 5-horsepower motor requires 1.5 horsepower hours per ton of corn processed. This roller mill would require 1,082 kWh of electricity per year to process the corn for 350 steer calves.

It is best not to generalize from a specific recommendation because corn has characteristics that differ from other grains such as milo in feeding and storing. Flinty grain such as milo should be rolled or ground before feeding. Also, the need for processing of grains differs from one type of livestock to another.

Calculations

Tractor-powered grinder:

20,000 bu of corn x 56 lb/bu ÷ 2,000 lb/ton = 560 tons of corn

Coarse grinding requires 9 hp per ton

10 tons/hr x 9 hp/ton = 90 hp/hr

90 hp at standard engine speed from a 100-hp diesel tractors uses 6.2 gal/hr

560 tons of corn ÷ 10 tons of corn ground per hour x 6.2 gal/hr = 347.2 gal of diesel fuel

Electric powered hammer mill:

560 tons of corn x 3.75 hp hr/ton of corn x 1.288 kWh/hp = 2,704.8 kWh

Electric powered roller mill:

560 tons of corn x 1.5 hp hr/ton of corn x 1.288 kWh/hp = 1,081.9 kWh

(continued on page 16)

Dollar Costs at Various Prices for Diesel Fuel and Electricity

Diesel Tractor Mill

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$138.88	$156.24	$173.60	$190.96

Electric Hammer Mill

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$81.14	$108.19	$135.24	$162.29

Electric Roller Mill

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$32.46	$43.28	$54.10	$64.91

Nonenergy Costs: Not grinding shelled corn should save an additional $300-$500 in repairs and labor cost; another $300-$600 in overhead costs if you do not have a mill and do not buy one.

EXAMPLE OF ENERGY SAVINGS THROUGH FEEDING HOGS FREE CHOICE

$98.04 to $129.20 in energy saved per year by feeding free choice instead of ground and mixed rations to 100 litters of hogs

The question of whether to grind corn and prepare a complete ground and mixed ration for hogs cannot be answered with a simple yes or no. There are places both for complete ground and mixed rations, and for corn- and supplement-fed free choice with no processing.

Producers with the larger hog enterprises often find a cost advantage in using corn and soybean meal plus extra ingredients to make a fully balanced swine feed. When soybean meal is used as a part of the ration, it is necessary to grind the grain and mix all ingredients together. Soybean meal is very palatable to hogs, and they will consume far too much of it if allowed to do so on a free choice basis.

Many hog producers, particularly those with the small-to-medium-sized enterprises, use commercially prepared supplements to add to grain. Grains and commercial supplements are often ground and mixed into complete rations. Whole grain and commercial supplement also may be fed separately on a free choice basis. Commercially prepared supplements are formulated so that hogs will eat only what they need. When using commercial supplements, look closely at the cost of grinding and mixing versus any benefits gained from this operation. Complete rations may improve efficiency, but free choice feeding may equal the performance of complete ground and mixed rations.

A 100-litter farrow-to-finish hog enterprise will require about 347 tons of feed, 10,000 bushels of corn (280 tons) and 67 tons of supplement. Medium-fine grinding and mixing of these feedstuffs with a tractor-powered mobile grinder-mixer will require about 12 horsepower per ton--48 horsepower for a 4-ton per hour output. A 50-horsepower diesel tractor will take 87 hours to do the job and use 3.3 gallons of fuel per hour. Free choice feeding would save 287 gallons of diesel fuel a year.

If you decide to grind and mix, consider one of the small electrically powered feed mills instead of a tractor-powered mill. A 3-horsepower electric feed mill will grind and mix about 1,000 pounds of feed per hour. Processing a ton of ration requires six horsepower hours or 2,082 horsepower hours for 347 tons. This is the equivalent of 2,713 kWh of electricity if you are on single-phase service. Electricity may be less costly than diesel fuel depending upon your cost.

Calculations

Feed required:	10,000 bu corn	= 280 tons
	supplement	= 67 tons
	total rations	= 347 tons

Tractor grinder mixer: 12 hp/ton

4 tons/hr x 12 hp = 48 hp

50-hp tractor working at 48 hp burns 3.3 gal of diesel fuel per hour.

347 tons ÷ 4 tons/hr x 3.3 gal = 287.1 gal of diesel fuel

Electric mill (3 hp): 1,000 lb/hr or 6 hp hr/ton

6 hp hr x 347 tons = 2,082 hp hours

With single phase power: 2,082 hp hr x 1.303 kWh/hp hr = 2,713 kWh

With three phase power: 2,082 hp hr x 1.177 kWh/hp hr = 2,451 kWh

(continued on page 18)

Dollar Costs at Various Prices for Diesel Fuel and Electricity

Diesel Tractor Mill

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$114.84	$129.20	$143.55	$157.91

Single-Phase Electric Mill

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$81.39	$108.52	$135.65	$162.78

Three-Phase Electric Mill

Cents/kWH	3¢	4¢	5¢	6¢
Annual savings	$73.53	$98.04	$122.55	$147.06

Nonenergy Costs: Feeding free choice instead of grinding and mixing should eliminate $200 to $300 in repairs and labor costs; another $300 to $600 in overhead costs if a farmer buys a new mill. Examine gains in feed efficiency of a processed ration to see if cost is justified.

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EXAMPLE OF ENERGY SAVINGS BY FEEDING FREE CHOICE CORN AND PROTEIN SUPPLEMENT VERSUS CUSTOM GROUND AND MIXED HOG FEED

$88 in energy savings in gasoline per year in fattening 300 feeder pigs

Many farmers buy 40-50 pound feeder pigs in the fall and winter after corn harvest time and feed them out to market weight. Some, especially those who feed only a few hundred hogs annually, haul their corn to commercial feed mills regularly to have it ground and mixed with protein supplement before feeding.

A farmer who feeds two successive lots of 150 pigs and who hauls feed 25 miles round trip for processing could save 800 miles of truck travel and 40 hours of driving time by feeding grain and supplement free choice. This amounts to saving $80 to $100 in gasoline cost alone. In addition, energy required by the commercial feed mill to grind and mix the feed would be saved. Consideration also should be given to improvement in feed efficiency from a complete processed ration. Differences in feed efficiency are not measured in this example.

Calculations

Each lot of 150 pigs eats an average of about 2.5 tons of feed per week for 16 weeks.

1 trip with a 2-ton truck to feed mill per week x 32 weeks per year x 25 miles per trip = 800 miles

800 miles at 5 miles per gal = 160 gal of gasoline.

Savings at Various Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Annual savings	$80	$88	$96	$104

Nonenergy Costs: Eliminate the trips to the feed mill and get rid of 6 to 7 cents per mile in nonfuel operating costs. Reduce wear on the truck. Avoid a custom processing charge ($5 per ton). Free 80-100 hours a year spent at the mill or enroute. A farmer may find he can operate with a small truck instead of a large one. Differences in feed efficiency and protein costs, if any, will have to be weighed along with these costs.

MANAGING RANGE AND HERD

Most cattle are grazed year round on pasture, range, or crop residues.

Cow-calf operators often use a pickup truck for supplemental feeding and checking on the herd. Regular tuneups help save fuel. Keeping the carburetor in proper adjustment also helps save fuel.

It costs about $55 a year for every 1,000 miles the farmer drives the pickup truck. This assumes 10 miles per gallon and gas at 55 cents per gallon.

Ranchers need to haul hay long distances especially in the West. Some have extended the beds of their farm trucks and added a section over the cab to increase bale capacity. Fuel use increases per load, but fuel and other costs per bale are reduced.

EXAMPLE OF ENERGY SAVINGS THROUGH CHANGING SUPPLEMENTAL FEEDING OF BEEF COWS

$170.50 to $293.92 in energy saved per year per 300-cow beef cattle herd

Much of the fossil fuel used in beef cattle production is used in getting supplemental feed to cattle on the range.

To save fuel, operators may limit range feeding to every other day, using salt to limit consumption of concentrates or using supplements designed for free choice feeding. If self-limiting dry concentrates are fed, the operators would have to invest in self-feeders, but the savings in fuel and labor would eventually offset this.

As an example, a 300-cow beef cattle operator in the Southwest High Plains of Texas may feed 1.56 pounds of 41 percent cottonseed cake per mature animal each day for 120 days this winter. This requires about 274 hours of pickup use. Since a 3/4-ton pickup can carry the 1,120 pounds of feed every other day almost as easily as the 560 pounds every day, the potential for savings in fuel is considerable.

Adding one-half pound of salt for each pound of meal results in the pickup being something less than half loaded. If the rancher changes his self feeders so that the feeders will hold a full pickup load, he can reduce his feeding trips from 120 to 50.

A 1.5-ton truck equipped with a tank could dispense enough liquid feed in four trips to supply the supplemental feed requirements of the breeding herd for 1 month, rather than making a trip out to feed every day. Each rancher must figure whether the differences in the cost of these feedstuffs will be offset by his fuel savings.

Calculations

Feed concentrates every day for 3 months: 2.28 hours per day x 120 days x 2.5 gal per hour = 685 gal

Feed every other day: 2.5 hours per day x 60 days x 2.5 gal per hour = 375 gal
Gasoline saved: 685 gal - 375 gal = 310 gal

Load self-feeders as required: 2.28 hours per load x 50 loads x 2.5 gal per hour = 285 gal
Gasoline saved: 685 gal - 285 gal = 400 gal

Feed liquid feed for 3 months: 5.02 hours per day x 12 days x 2.5 gal per hour = 150.6 gal
Gasoline saved: 685 gal - 157.6 gal = 534.4 gal

Gasoline Savings at Various Prices

Regular Bulk Delivery

Cents/gal	50¢	55¢	60¢	65¢
Annual savings (feeding every other day)	$155.00	$170.50	$186.00	$201.50
Annual savings (using self-feeders)	$200.00	$220.00	$240.00	$260.00
Annual savings (using liquid supplement)	$267.20	$293.92	$320.64	$347.36

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EXAMPLE OF ENERGY SAVINGS FROM TWO GRAZING SYSTEMS

$245.00 to $493.35 in energy saved per year per 300-cow beef cattle herd

Yearlong grazing of livestock herds on the range is a common practice in the Southwest. Range can be improved by deferring use of particular pastures during the growing seasons. An additional benefit is savings in labor and pickup operating expenses associated with supplemental feeding. While a reduction in livestock numbers may be required at the outset to avoid overgrazing, stocking rates can be increased over time as range condition improves over the original grazing system.

Let's examine two types of deferred grazing to show the fuel savings. The first is a four-pasture deferred-rotation grazing system, and the second is the one-herd, high intensity, low frequency (HILF) grazing system.

A 300-cow beef cattle herd in the Southwest High Plains of Texas encompasses 8,928 acres. Pastures are sufficient in number and size to allow at least three dispersed sets of four-pasture deferred-rotation grazing systems. By concentrating the breeding herd into three pastures for shorter periods rather than in all pastures yearlong, pickup use in supplemental feeding, and livestock supervision and handling can be reduced considerably.

By opening adjoining pasture gates, the ranch can be combined into a 6-pasture operation for HILF grazing. The entire beef cow herd can be grazed in each pasture for 4 weeks before moving them to the next pasture, thus providing periods of deferment. This offers an opportunity to feed cattle supplementally during the winter and to oversee them in one pasture at a time. Pickup fuel used in distributing feed and in supervising and handling cattle can be reduced significantly.

<u>Calculations</u>

<u>Herd dispersed over entire ranch</u>:

Feeding: 2.28 hours per day x 120 days x 2.5 gal per hour = 685 gal of gasoline

Supervision and handling: 1.22 hours per day x 365 days x 2.5 gal per hour = 1,112 gal of gasoline

Total gal of gasoline: 685 gal + 1,112 gal = 1,797 gal

<u>Four-pasture deferred-rotation grazing system</u>:

Feeding: 1.71 hours per day x 120 days x 2.5 gal of gasoline per hour = 512 gal of gasoline

Supervision and handling: .92 hours per day x 365 days x 2.5 gal per hour = 840 gal of gasoline

Total gal of gasoline: 512 gal + 840 gal = 1,352

Gasoline saved: 1,797 - 1,352 = 445 gal

<u>HILF grazing system</u>:

Feeding: 1.14 hours per day x 120 days x 2.5 gal per hour = 342 gal of gasoline

Supervision and handling: .61 hours per day x 365 days x 2.5 gal per hour = 558 gal of gasoline

Total gal of gasoline: 342 gal + 558 gal = 900 gal of gasoline

Gasoline saved: 1,797 gal - 900 gal = 897 gal

(continued on page 23)

Gasoline Savings at Various Prices

Regular Bulk Delivery

Cents/gal	50¢	55¢	60¢	65¢
Four-Pasture Deferred Rotation Grazing System				
Annual savings	$222.50	$244.75	$267.00	$289.25
HILF Grazing System				
Annual savings	$448.50	$493.35	$538.20	$583.05

Nonenergy Costs: If fencing is already adequate, fuel savings are a net gain. In addition, the four-pasture system saves $124 in truck repairs and lubrication plus $400 in labor at $2.25 per hour. HILF saves $250 in truck costs; $809 in labor at $2.25 an hour.

EXAMPLE OF ENERGY SAVINGS BY CHANGING TO A LOW-VOLUME APPLICATION OF HERBICIDES TO CONTROL BRUSH

$1,357.06 in energy saved per year per 300-cow beef cattle herd

Brush and other noxious plants compete for water, soil nutrients, light, and space with range and pasture forage plants. Heavy infestations of brush, such as mesquite, white brush, and scrub oak have reduced range-carrying capacities to the point that ranch operators must control brush or reduce stocking rates. Aerial applications of herbicides are used. The material usually is mixed with diesel oil or diesel oil and other carriers such as water. This practice of using carriers extends the herbicide more uniformly over the treatment area and facilitates adherence of the herbicide to plant leaves for increased effectiveness.

A 300-cow beef cattle ranch in Southwest Texas has a mesquite infestation. Part of the ranch is sprayed each year. Deferment of grazing usually follows brush control treatment, so one pasture may be treated and rested before another one is treated. The rancher would spray 744 acres, one of his 12 pastures, each year. Experiments show that the amount of carrier can be reduced from 5 gallons per acre to 1 gallon per acre without reducing the coverage or the effectiveness in brush kill appreciably. Reducing diesel oil used as a carrier saves both diesel oil and flight fuel used in herbicide application. While this is a custom operation, the savings here are reflected in the custom rate charged.

Calculations

Spray mesquite with full carrier:

5 gal diesel oil per acre x 744 acres = 3,720 gal of diesel

.14 gal aviation gasoline per acre x 744 acres = 104.16 gal

Spray mesquite with low-volume carrier:

1 gal diesel oil per acre x 744 acres = 744 gal of diesel

.10 gal of aviation gasoline per acre x 744 acres = 74.4 gal of gasoline

Fuel saved: 3,720 gal of diesel - 744 gal of diesel = 2,976 gal of diesel

104.16 gal of gasoline - 74.4 gal of gasoline = 29.76 gal of gasoline

Energy Savings at Various Prices

	Diesel Fuel			
Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$1,190.40	$1,339.20	$1,488.00	$1,636.80
	Aviation Fuel			
Cents/gal	55¢	60¢	65¢	70¢
Annual savings	$16.37	$17.86	$19.34	$20.83
Total annual savings	$1,206.77	$1,357.06	$1,507.34	$1,657.63

VENTILATING AND HEATING

In most beef cattle and sheep operations, little or no mechanical ventilation or supplemental heat is required. But in some of the new confined housing systems the energy requirement is high. Heating and ventilation are large energy users in confinement hog production, especially for farrowing houses and nursery buildings. The electrical power needed to ventilate a total confinement farrow-to-finish hog facility producing 1,600 head a year in the central Corn Belt is about 55,000 kilowatt-hours a year. Heating for the farrowing house and nursery building requires about 2,100 gallons of LP gas plus 3,700 kilowatt-hours of electricity to operate heater fans and heat lamps.

Operation

Ventilation of a livestock building helps to remove both heat and moisture. During the summer, heat removal is the major concern. In the winter, moisture removal takes precedence. Because of heat loss through the walls and roof and cold incoming fresh air, supplemental heat may be needed. This causes condensation to form in the building. Insulation reduces heat loss and thus will reduce supplemental heat needs. A general rule: If you ventilate, insulate.

Fans used in livestock buildings are rated by the cubic feet of air they move per minute. Most are run by electric motors, and many have two or more speeds. Fans should be operated only when necessary. Ventilating fans usually are controlled by a thermostat which turns on the fans whenever the barn temperature goes above a set level.

Maintenance

Electric fan motors should be checked and oiled regularly. They are probably run more hours than any other electric motor and receive less attention. Cleaning off dust and oil that builds up on the fan blades will save 5 to 10 percent on energy in winter months, and help fans move more air in the summer months. Cleaning of the louvers to make them operate more smoothly and accurately will improve a fan's efficiency.

Supplemental heat may be provided by gas or electric heaters. Fired heaters need routine checkups, just like any furnace. Turning off the whole system, pilot light included, will save energy in the summer. In damp locations consider possible corrosive effects of leaving the pilot light off for extended periods. Cleaning of filters and air vents will improve the heating unit's efficiency. Resistance electrical heating is usually more expensive than fired heating for large areas.

Planning

Planning a new facility? Look carefully at the ventilation and supplemental heating needs. Warm confinement barns may provide a better environment for feeder cattle than cold barns. However, the cost of power to ventilate and heat will more than offset any advantage of warm confinement. Hogs benefit greatly from proper control of temperature and ventilation. Both heating and ventilation should be top priority items in planning a hog production facility.

If a new facility includes ventilation by variable speed fans, check to make sure the fan is controlled by a solid controller rather than a straight resistant unit. The motor controlled by a straight resistant unit wastes energy at low speed.

Insulation

The tabulation on page 27 provides information on the insulating value of various material.

An R-value of 12-14 is recommended for the walls and 16 or more for the ceiling.

The R-value of a material is a measure of its capacity to resist heat flow. Figure 3 and the tabulation on page 27 present 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. The vapor barrier should allow less than 1/2 perm of moisture vapor to pass through the material. (A perm is the amount of moisture vapor in grains that will pass through a square foot of material in 1 hour when the pressure difference is 1 inch of mercury.)

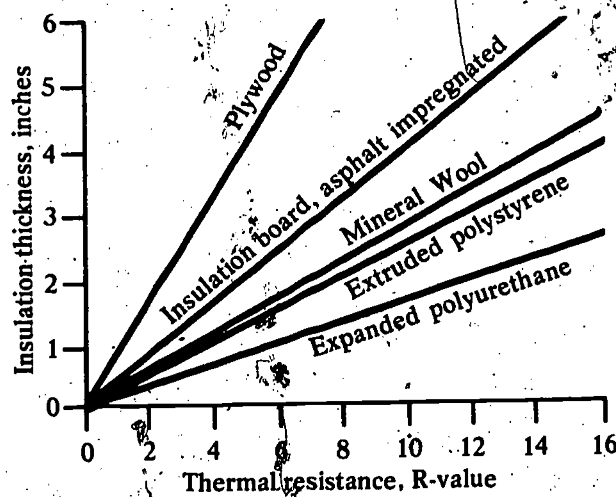

Figure 3. RELATIONSHIP BETWEEN THERMAL RESISTANCE, R-VALUE, AND THICKNESS OF INSULATION FOR CERTAIN MATERIALS.*

* Carr, Lewis E., Kenneth E. Felton, and James L. Nicholson, Planning for Fuel Conservation in Your Broiler House, MEP-320, p. 12, Cooperative Extension Service, Univ. of Maryland, College Park, MD., 1974.

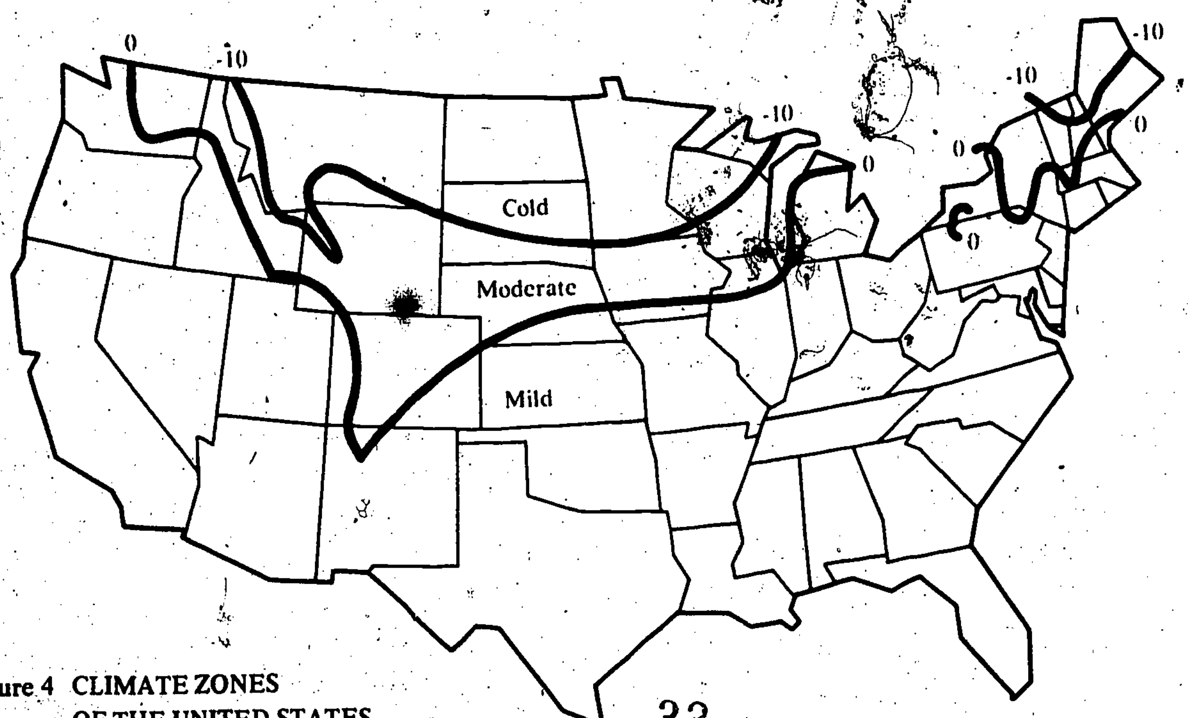

Figure 4 CLIMATE ZONES OF THE UNITED STATES

Insulation Value of Materials Material	Thickness (inches)	Resistance rating (R)
Air space, enclosed by ordinary materials		
Air space, aluminum foil one side	3/4 - 4	0.91
Air space, aluminum foil both sides	3/4 - 4	2.17
Surface film, inside, nonreflective (gen. val.)	3/4 - 4	2.44
Surface film, inside, reflective		0.61
Surface film, outside, 15 mph wind		1.10
Asbestos-cement board		0.17
Gypsum board or sheet rock	1/8	0.03
Gypsum board or sheet rock	3/8	0.32
Plywood	1/2	0.45
Plywood	1/4	0.31
Plywood	3/8	0.47
Hardboard	per inch	1.24
Insulation board, sheathing regular density	1/8	0.09
Blanket insulation, mineral (rock) wool, or glass	1/2	1.32
Loose fill insulation, wood fiber	per inch	3.70
Loose fill rock wool or glass wool	per inch	3.33
Loose fill, vermiculite expanded	per inch	3.70
Sawdust or shavings	per inch	2.13
Foam insulation, expanded polyurethane	per inch	2.22
Foam insulation, expanded polystyrene extruded plain	per inch	6.25
Common brick	per inch	4.00
Face brick	4	0.80
Clay tile	4	0.44
Clay tile	4	1.11
Concrete blocks, regular	8	1.85
Concrete blocks, lightweight	8	1.11
Concrete, regular	8	2.00
Sheathing or flooring, softwood	8	0.64
Sheathing or flooring, hardwood	3/4	0.94
Drop siding, 1 x 8	3/4	0.68
Bevel siding 1/2 x 8	3/4	0.79
Bevel siding 3/4 x 10	3/4	0.81
Building paper		1.05
Roll roofing, asphalt		0.06
Built-up roofing		0.15
Asphalt shingles, 3 tab	3/8	0.33
Wood shingles, 7-1/2 inch exposure	3/8	0.44
Metal roofing		0.87
Window, single glass		Negligible
Window, single glass with storm sash		0.10
Polyethylene vapor barrier		1.54
Rolled side wall curtain		Negligible
		Negligible

Source: Carr, Lewis E., Kenneth E. Felton, and James L. Nicholson, Planning for Fuel Conservation in Your Broiler House, Coop. Ext. Serv., Univ. of Md., College Park, Md., 1974, MEP-302, pp. 21-22. Compiled from ASRAE Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc. 1972 ed., pp. 357-364. Jennings, Burgess H. and Samuel R. Lewis, Air Conditioning and Refrigeration, 4th ed., 2nd printing 1959, International Textbook Co., Scranton, Pa., pp. 91-108, 152-153.

EXAMPLE OF ENERGY SAVINGS BY SHUTTING OFF PILOT LIGHT ON SPACE HEATER

The pilot light on your space heater burns 5 or more gallons of LP gas per month. This energy is not wasted in the winter months when you need the heat, but it is in the summer.

The whole system can be turned off by shutting off the valve between the storage tank and the gas line leading to your space heater.

One farmer reported a monthly LP gas bill of $5 to $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.

$14.00 in energy saving per summer season

Calculations

5 gal of LP gas/month x 7 months = 35 gal of LP gas

35 gal of LP gas x $.40/gal = $14

Dollars Saved at Various LP Gas Prices

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$12.45	$14.00	$15.75	$17.50

EXAMPLE OF ENERGY SAVINGS BY INSULATING A FARROWING HOUSE

$1,276 in energy savings through proper insulation versus no insulation of a 40-crate farrowing house in Illinois

Insulation will keep a farrowing house warmer in winter and cooler in summer. This will cut supplemental heating needs and reduce ventilation requirements.

Adding insulation to existing walls is difficult, and in some cases impossible. In new buildings adequate insulation should be put into the walls. Insulation to an "R" value of 12 to 14 is recommended. Storm windows or plastic covers on windows will approximately halve the heat loss through windows. Seal cracks around windows and doors for added protection. The ceiling of existing buildings can usually be insulated with little difficulty. The ceiling should be insulated to an "R" value of 16 or more.

In most buildings the floors are of concrete slab, and no insulation can be added. When building a new structure, use crushed rock or other substance that will add dead air space below your floors to act as insulation.

A 40-crate (26 x 120 feet) uninsulated farrowing house will require nearly twice as much heating and cooling as one that is properly insulated. In Illinois, the heating of an uninslated farrowing house would consume about 2,400 gallons of LP gas during a typical winter season and as many as 5,800 kilowatt-hours of electricity for heating. Adequate ventilation could take as much as 34,000 kilowatt-hours. Proper insulation could cut the amount of gas and electricity needed in half.

The cost involved in insulation is substantial. It can be a dollar or more per square foot of floor space.

<u>Calculations</u>

2,400 gal of LP gas x .5 saved = 1,200 gal LP gas saved

5,800 kWh x .5 saved = 2,900 kWh saved

3,400 kWh x .5 saved = 17,000 kWh saved

2,900 kWh saved + 17,000 kWh saved = 19,900 kWh saved

1,200 gal of LP gas saved x $.40 per gal = $480

19,900 kWh saved x $.04 per kWh = $796

<u>Energy Savings at Various Prices</u>

Electricity				
Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$597	$796	$995	$1,194
LP Gas				
Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$420	$480	$540	$600
Total annual savings	$1,017	$1,276	$1,535	$1,794

Nonenergy Costs: One has to buy adequate insulation. It will cost $3,000 to $3,500 to do the job for a 40-crate farrowing house. Annual overhead cost will be $468 to $570 if you assume a 10-year life and 10 percent interest--a net cost advantage of $706 to $808 per year for proper insulation. An added benefit is more effective summer ventilation.

EXAMPLE OF ENERGY SAVINGS IN COLD VERSUS WARM CONFINEMENT BARNS FOR CATTLE FEEDING

$1,217.52 in energy savings for a cold versus a warm confinement barn with capacity for 200 feeder cattle

Total confinement has some advantages over feeding beef cattle in shed-and-lot or open-lot system. Warm barns are fully enclosed with most of the ventilation provided by fans. Cold confinement barns are full roofed, but are open on the sides except for drop curtains to shield cattle from the wind. Ventilation fans are not necessary in cold barns. Animals do better in warm barns.

However, gains are not enough to offset the added cost of the warm building, especially the power required for ventilation. Winter ventilation requires air movement of at least 15 cubic feet per minute per animal while summer ventilation needs are a minimum of 1,200 cubic feet per minute per animal plus pit fans. With a 200-head warm confinement cattle barn, ventilation requirements will average about 30,000 cubic feet per minute for the year.

Fans differ as to the amount of air they will move, but for estimating purposes a 1.0 horsepower fan operating at 0.1 inches of static pressure can be credited with 20,000 cubic feet per minute. Thus, the equivalent of a 1.5 horsepower fan would be needed year-round for a 200-head warm confinement barn. That translates into 13,140 horsepower hours or 24,178 kilowatt hours--more if thermostat-controlled motors are used during winter when less air movement is needed.

Supplemental heat is needed to maintain condensation control at temperatures below 10°F, if indoor conditions are to be maintained above 35°F. Supplying the recommended 400 British thermal unit per hour per animal for 30 days in a moderate climate would take 626 gallons of LP gas.

<u>Calculations</u>

<u>Cost to heat a warm barn:</u>

400 Btu/hr x 24 hr x 30 days x 200 head = 57.6 million Btu ÷ 92,000 Btu = 626 gal LP gas. 626 gal LP gas x $.40 = $250.40.

<u>Cost to ventilate a warm barn:</u>

Average air movement per animal = 150 cubic feet per minute

200 head x 150 cubic feet per minute per head = 30,000 cubic feet per minute

Output of 1.0 hp fan = 20,000 cubic feet per minute

1.5 hp x 365 days x 24 hours = 13,140 horsepower hours

13,140 hp hours x 1.84 kWh per hp = 24,178 kWh

24,178 kWh x $0.04 per kWh = $967.12

<u>Cost to heat and ventilate a cold barn:</u>

none

<u>Energy Savings at Various Prices</u>

LP Gas				
Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$219.10	$250.40	$281.70	$313.00

Electricity				
Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$725.34	$967.12	$1,208.90	$1,450.68

Total annual savings	$944.44	$1,217.52	$1,490.60	$1,763.68

Nonenergy Costs: A cold confinement barn for 200 feeder cattle will cost about $10,000 less than a warm barn. Annual costs for the cold barn are $1,500 less than for the warm barn in addition to reduced energy costs.

Source: Beef Housing and Equipment Handbook, MWFS-6, Midwest Plan Service, Iowa State Univ., Ames, Iowa, 1968, p. 9.

Example of energy saving: Relamping opportunities
(All costs are figures at 4 cents per kilowatt-hour. The annual savings include normal ballast loss.)

Area	Relamp from	To	To save annually	Approximate investment necessary
12 hours daily use				
Night light	2 300-watt incandescent floodlights	1 250-watt mercury vapor	$59.96	$115 to $130
6 hours daily use				
Outside lighting	1 200-watt incandescent	1 100-watt mercury vapor	$7.96	$50 to $70
3 hours daily use				
Farrowing house (20 crate)	8 100-watt incandescent	4 40-watt fluorescent	$25.68	$40 to $48
2 hours daily use				
Nursery (1,000 ft^2)	6 100-watt incandescent	3 40-watt fluorescent	$12.84	$30 to $36
Hog barn (3,000 ft^2)	16 100-watt incandescent	8 40-watt fluorescent	$34.24	$80 to $96
Feed house (1,000 ft^2)	1 100-watt incandescent	1 20-watt fluorescent	$2.20	$8 to $10
1 hour daily use				
Cattle shed (3,000 ft^2)	6 100-watt incandescent	3 40-watt fluorescent	$6.42	$30 to $36
Hay shed (3,000 ft^2)	3 150-watt incandescent	1 175-watt mercury vapor	$3.85	$65 to $80
Shop	4 100-watt incandescent	2 40-watt fluorescent	$4.28	$20 to $24

Note: Some of the relampings are not economical at current prices. These were included to give information that can be used in planning for the needs of future building or remodelings. Also, the life of fluorescent and mercury and sodium vapor lamps is much longer than incandescent lamps. However, fluorescents do not work well in cold barns.

LIGHTING

Try to cut lighting costs by a fourth. While they are a small part of a livestock producer's total electric bill, the savings can be worth the effort. A 150-watt bulb left on overnight (12 hours) consumes 1.8 kilowatt hours, and this adds up to several hundred kilowatt hours or $20 to $30 in a year.

Use the lowest possible bulb wattage. Clean light fixtures, and eliminate unnecessary lights to reduce lighting bills. Inside, fluorescent bulbs provide four times the light of incandescent bulbs. Outside, where possible, use a mercury vapor lamp to provide twice as much light as an incandescent lamp per unit of energy used. Substitution of one 100-watt incandescent bulb for two 60-watt bulbs generates a 16 percent energy saving and provides approximately the same number of lumens.

Units used to measure lighting are lumens, watts, foot candles, and hours. The light output of a bulb is measured in lumens, and the amount of electricity consumed in watts. A foot candle indicates the lumens that fall on 1 square foot of surface. The life span of a bulb is measured in hours. Some of this information is printed on the light bulb package. A comparative reading of these packages may reveal that one kind of bulb has a longer life than a "soft" or tinted incandescent bulb of the same wattage.

Table 5--Comparison of characteristics of lamps

Type of lamp	Size by watts	Average output in lumens	Average hours of life	Average lumens per watt 1/
Incandescent (standard)	25	225		9
	40	430		11
	60	810	750	14
	100	1,600	to	16
	150	2,500	1,000 2/	17
	200	3,500		18
	300	5,490		18
Fluorescent (standard)	15	660		34
	20	1,000	18,000	40
	40	3,200		60
Mercury (clear)	75	2,800		
	100	3,800		
	175	7,500	24,000	40
	250	11,600		45
	400	21,000		50
	700	39,000		
Metal halide	175	12,000		
	400	34,000	15,000	75
	1,000	95,000		
Sodium (high-pressure)	250	25,500		
	400	47,000	16,000	100
	1,000	130,000		

1/ Includes ballast requirements, if necessary; rating not available for all size and types of lamps.

2/ Longer life lamps (up to 3,500 hours) are available at a high initial cost. They produce 10-15 percent fewer lumens per watt.

Source: Campbell, Lowell and Henry M. Cathey, "Outdoor Lighting Has Many Roles," 1973 Yearbook Agriculture, USDA Yearbook Separate No. 3854 p. 190.

Before changing lighting, walk around facilities, both indoors and outdoors. Note the areas which appear over- or under-lighted. An individual evaluation of the amount of light needed may be adequate. To be more accurate, use a light meter. With the aid of a simple light meter and the tabulation below, you can match the amount of light provided to specific tasks to be performed.

Two simple rules will help one to use a light meter and the above tabulation more effectively.

1. To obtain an accurate measure, hold the light meter 30 inches away from a wall and 30 inches from the floor.

2. Also, try to determine the age of the bulbs in each area. If they are old, their light will be weak and give an inaccurate indication of the lighting level when new bulbs are installed.

Recommended Illumination Levels

Area or visual task	Foot candles
Feeding, inspection, and cleaning	20
Reading charts and records	30
Close inspection of animals	50
Washing and sanitizing 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

Source: Krewatch, Albert V., "Farm Lighting," Farmers Bulletin 2243, USDA, Dec. 1969, pp. 10-12.

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EXAMPLE OF ENERGY SAVINGS BY CAREFUL ATTENTION TO LIGHTING USE *

One farmer reported a savings of 400 kilowatt hours on his electrical bill when his hired man quit and he had to hire a different one. Apparently, the first hired man had a hard time remembering to turn off the lights. This 400-kilowatt hour decrease may seem like an unduly large amount, but when it is broken down to the amount of 100-watt bulbs that would have to be on continuously, it is not unreasonable. Just six 100-watt bulbs being used continuously would consume 5,256 kilowatt hours in a year.

*See other examples of lighting con- servation on page 32.

$210.24 in energy savings per year by careful attention to lighting

<u>Calculations</u>

100 watts x 24 hours per day x 6 bulbs = 14,400 watt-hours per day

14,400 watt-hours per day x 365 days ÷ 1,000 watts = 5,256 kW

5,256 kW x $.04 kWh = $210.24 per year

<u>Energy Savings at Various Electrical Rates</u>

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$157.68	$210.24	$262.80	$315.36

SAVING ENERGY IN LIVESTOCK OPERATIONS

DRYING GRAIN

Corn harvest usually begins when grain moisture is 28 to 30 percent. By the end of the harvest season the moisture of corn in the field is usually around 18 percent. Harvested corn usually averages 23 percent moisture content.

Corn to be sold at harvest must be dried to 15.5 percent moisture or sold at a discount. To be stored on the farm, it is normally dried to 13 to 15.5 percent moisture depending upon how long it is to be stored. Usually, 8 to 10 percentage points of moisture are removed from corn during the drying process.

Grain drying is too complex a process and done in too many ways to make a thorough set of recommendations here. Nevertheless, a few examples to show the possibilities for energy savings follow.

EXAMPLE OF SAVING ENERGY THROUGH THE FEEDING OF HIGH MOISTURE CORN 2/

$47.57 to $522.11 net energy savings from feeding high moisture corn versus high temperature drying

A farmer harvests, dries, and feeds 20,000 bushels of No. 2 corn each year to finish 350 steer calves to slaughter weight or produce 200 litters of hogs in a farrow-to-finish operation. If he removes 9.5 points of moisture, from 25 to 15.5 percent moisture, he starts with about 22,660 bushels of wet corn.

If he uses a batch-in-bin drying system, he has $24,850 invested in equipment with an annual cost of $2,955 for this fixed investment. The operating costs for this system are $2,753 of which LP gas is $1,507 (0.0175 gallon of LP per point of moisture removed at $.40 per gallon of LP) and $227 is for electricity (.15 kilowatt hour of electricity per bushel for the dryer and .1 kilowatt hour per bushel for aeration during storage). The total annual costs of No. 2 corn for this system is $.285 per bushel.

As long as the corn is going to be fed to cattle or hogs, drying is not the only preserving method one can use. High moisture corn can be placed in an air-tight storage structure and preserved through fermentation. Propionic acid allows preservation of high moisture corn without fermentation. The animals will gain the same no matter which preserving method is used.

2/ Material for this example was provided by Julius Edwards from his Master's thesis, "Economics of Energy Use Under Selected Alternative Technologies for Illinois Hog Production," Univ. of Illinois.

For an oxygen-free corn storage system using a 25 by 65-foot upright silo, the investment costs are $38,610 for equipment with an annual cost of $4,184 for this fixed investment. The operating costs are $1,476 of which diesel fuel is $70 to operate the tractor-powered blower for 45.7 hours. The total annual costs per bushel equivalent of No. 2 corn for this system is $.283. Cost of the two systems are essentially the same, but drying takes $1,734 of the energy annually; the high moisture system, $70. A price for propionic acid of $.36 per pound makes acid treating of corn much more expensive than drying or fermenting the corn. However, acid treating can be used with many existing storage structures on farms and may be justifiable under some conditions such as a shortage of gas. Also acid-treated corn may be sold to another farmer for feeding more easily than fermented corn.

A farmer can reduce energy use by feeding high moisture corn. However, he may reduce flexibility in marketing his crop, may create complications in ration formulation, and may precipitate changes in methods of feeding. Weigh the options carefully before making a change.

(continued on page 38)

Calculations

High temperature drying:

25 percent beginning moisture corn - 15.5 percent ending moisture corn = 9.5 percentage points of moisture removed.

9.5 percentage points of moisture removed x 0.0175 gal of LP gas per percentage point of moisture removed x 22,660 bu of 25 percent corn = 3,767.225 gal of LP gas.

3,767.225 gal of LP gas x $.40 per gal of LP = $1,506.89.

(0.15 kWh of electricity for dryer + 0.1 kWh of electricity for aeration) x 22,660 bu of 25 percent corn = 5,665 kWh.

5,665 kWh x $.04 per kWh = $226.60

Oxygen-free storage

45.7 hours needed to fill silo x 3.4 gal of diesel consumed by a 50-hp tractor operating at full power = 155.38 gal of diesel.

155.38 gal of diesel x $.45 per gal = $69.92.

Costs and Savings at Various Energy Prices

High-Temperature Drying

LP Gas

Cents/gal	**35¢**	**40¢**	**45¢**	**50¢**
Costs	**$1,318.53**	**$1,506.89**	**$1,695.25**	**$1,883.61**

Electricity

Cents/kWh	**3¢**	**4¢**	**5¢**	**6¢**
Costs	**$ 169.95**	**$ 226.00**	**$ 283.25**	**$ 339.90**
Annual drying costs	**$5,462.48**	**$5,707.49**	**$5,992.50**	**$6,197.57**

Oxygen-Free Storage

Diesel Fuel

Cents/gal	**40¢**	**45¢**	**50¢**	**55¢**
Costs	**$ 62.15**	**$ 69.92**	**$ 77.69**	**$ 85.46**
Annual oxygen-free storage costs	**$5,652.15**	**$5,659.92**	**$5,667.69**	**$5,675.46**
Net savings--drying versus oxygen-free storage	**-$ 189.67**	**$ 47.57**	**$ 284.81**	**$ 522.11**

EXAMPLE OF SAVING ENERGY THROUGH BETTER PLANNING OF THE CORN HARVEST PROGRAM

Corn that has matured can be handled by modern combines when the moisture level is as high as 30 percent, but kernel breakage is high and harvesting losses are increased. One might profitably delay harvest a few days. During the early fall, temperatures are usually rather high. The rate of field drying is also high. Delaying harvest for a week or 10 days may mean harvesting 25 instead of 30-percent moisture corn. With a relatively small crop, most producers can wait awhile and still get the crop into storage well before bad weather and the high loss period that occurs later in the year. Even a 2-row corn combine can harvest 20,000 bushels of corn from land yielding 100 bushels per acre in just about twelve 10-hour days.

Most of the corn on a farm will be harvested at the same moisture content. Waiting a week or 10 days, however, can well mean that the first 5,000 bushels comes in at an average of 23 instead of 28 percent moisture. It takes about 1.75 gallons of LP gas and 1.50 kilowatts of electricity to remove one point of moisture from 100 bushels of corn in a high-temperature drying system. Letting 5,000 bushels of corn field dry an extra 5 percentage points can thus save you about 438 gallons of LP gas and 360 kilowatts of electricity. Also, the dryer corn will combine with less damage and loss, and it will contain less trash and fines thereby reducing problems in storage.

$190.20 in energy savings per year by delaying corn harvest and letting	5,000 bushels of corn field dry another 5 percentage points

Calculations

5 points x 5,000 bu x 1.75 gal of LP gas = 438 gal

5 points x 5,000 bu x 1.50 kWh = 375 kWh

Energy Savings at Various Fuel Prices

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$11.25	$15.00	$18.75	$22.50

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$153.30	$175.20	$197.10	$219.00
Total savings	$164.55	$190.20	$215.85	$241.50

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EXAMPLE OF SAVING ENERGY THROUGH SELECTING THE RIGHT SIZE OF STORAGE BINS FOR CORN

$386 in net energy savings per year by varying ending moisture levels and storing 20,000 bushels of corn in three bins instead of one.

A 20,000 bushel bin plus perforated floor and aeration fan presently costs about $12,000. Three 6,670 bushel bins similarly equipped cost about $15,000 or $3,000 more.

The initial cost savings provide a strong incentive for building large grain bins, but they may cost more than smaller bins in extra drying costs. Corn to be stored through the hot summer months must be dried to 13 or 14 percent moisture, or it may not keep.

Corn can be stored satisfactorily at much higher moisture levels without either spoiling or fermenting if it can be kept cool. For example, corn containing 20 percent moisture can be kept in storage about 60 days if it can be cooled quickly to 45°F. This is easy to accomplish with night air in the latter part of the harvest season in the Corn Belt. The bin containing cool, high moisture corn can then be fed out before warm weather comes.

Several small bins rather than one large bin provide the flexibility to vary moisture content of corn according to use periods. Drying 20,000 bushels of No. 2 corn equivalent from an average harvest moisture of 23.5 percent (22,200 bushels of wet corn) to 14 percent moisture for year-round storage takes about 3,691 gallons of LP gas and 3,164 killowatt hours of electricity.

Suppose instead one uses three 6,670 bushel bins. Early harvest corn averaging 25 percent moisture is dried to 14 percent and put in one bin for summer feeding. Mid-harvest corn averaging 23 percent is dried to 18 percent, cooled as the season progresses, and kept for feeding in the spring. Late harvest corn averaging 20 percent moisture is put in the third bin directly from the combine, cooled with natural air and fed during the winter. Aeration is necessary for all corn regardless of moisture or bin size.

The three-bin system results in an annual savings of about $806 for drying--1,856 gallons of LP gas and 1,591 kilowatts of electricity. The annual cost of the $3,000 additional investment in smaller bins at 14 percent is $420. Net gain for the flexible system is about $386 a year.

Calculations

One-bin system:

20,000 bu of No. 2 corn = 22,200 bu of 23.5 percent corn

Average beginning moisture - 23.5 percent

Average ending moisture - 14.0 percent

Moisture removed: 23.5 to 14.0 = 9.5 points

9.5 points x 22,200 bu x 1.75 gal LP per hundred bu per point = 3,691 gal LP

9.5 points x 22,200 bu x 1.50 kWh per hundred bu per point = 3,164 kWh

Three-bin system:

Summer: 6,670 bu No. 2 corn = 7,560 bu of 25 percent corn

Spring: 6,670 bu No. 2 corn = 7,360 bu of 23 percent corn

Winter: 6,670 bu No. 2 corn = 7,080 bu of 20 percent corn

Summer: 25-14 = 9 points (moisture)

9 points x 75.6 hundred bu x 1.75 gal of LP per hundred bu per point = 1,191 gal LP

9 points x 75.6 hundred bu x 1.50 kWh per hundred bu per point = 1,021 kWh

Spring: 23-18 = 5 points (moisture)

5 points x 73.6 hundred bu x 1.75 gal LP per hundred bushel per point = 644 gal LP

5 points x 73.6 hundred bu x 1.50 kWh per hundred bushels per point = 552 kWh

Winter: No drying

Total energy use: 1,835 gal LP gas and 1,573 kWh electricity

Difference: 1,856 gal LP gas and 1,591 kWh of electricity

Added investment cost: $3,000 additional for smaller bins x .14 investment cost = $420

Energy savings: $806.04 - $420 = $386.04 per year

Dollars Saved at Various Fuel Prices

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$649.60	$742.40	$835.20	$928.00

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$47.73	$63.64	$79.55	$95.46
Total savings	$697.33	$806.04	$914.75	$1,023.46

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IRRIGATING WITH SPRINKLERS

Energy demands for sprinkler irrigation can be high. Because of the availability of water, either because of a permit allocation or its relatively low cost, irrigators may not always employ the best water management techniques. Many times too much water goes on a field only to run off or evaporate. Excess water pumping may be more expensive than many irrigators realize. Irrigate strictly according to crop and soil needs to reduce annual water application and energy cost substantially without lower yields. High yields of pasture and hay crops require supplemental irrigation throughout much of the Western half of the United States.

Table 6--Diesel fuel required per acre for 1 foot of water applied at various pressures 1/

Lift (feet)	20 psi	40 psi	60 psi	80 psi	100 psi
	Gallons				
50	15	22	28	35	42
100	22	29	36	43	50
200	37	44	51	58	65
300	52	59	66	73	80
400	68	74	81	88	95
500	83	90	96	104	111

1/ One gallon of diesel fuel produces about the same work as 1.4 gallons of gasoline.

Source: Energy Facts and Figures, EM-3943, Washington State Univ., Pullman, Wash., Aug. 1975.

Table 7--Kilowatt-hours per acre-foot of water applied at various pressures

Lift (feet)	20 psi	40 psi	60 psi	80 psi	100 psi
	Kilowatt-hours				
50	192	260	350	440	510
100	280	350	440	525	600
200	455	525	610	700	790
300	630	700	790	875	950
400	800	875	960	1,050	1,120
500	980	1,050	1,140	1,230	1,290

Source: Energy Facts and Figures, EM-3943, Washington State Univ., Pullman, Wash., Aug. 1975

EXAMPLE OF ENERGY SAVINGS BY USE OF AUTOMATIC TIMERS ON IRRIGATION PUMPS

$28.78 to $32.12 in net energy savings per year

Installation of timers to automatically switch off pumps can result in considerable energy savings. Not only does a timer eliminate the need to get up and turn off a pump during the inconvenient nighttime hours, but it also decreases overapplication of water which can result in plant and soil damage, and wasted energy use.

Consider a situation where the pumps run unnecessarily 25 hours a year because there is no one to attend the cut off switches. On a medium pressure well (60 pounds per square inch) and a 200-foot lift with a system delivering 500 gallons per minute, $53 in energy savings could be realized annually with a diesel pump; $56 with an electric pump.

The cost of automatic timers ranges from $9 to $31 plus installation costs of $3 to $5.

Calculations

Diesel-powered pump

25 hours x 60 minutes per hour x 500 gal per minute ÷ 326,000 gal per acre foot = 2.3 acre feet

2.3 acre feet x 51 gal of diesel per acre foot x $.45 per gal of diesel = $52.78

Net savings: $52.78 fuel savings - $24 timer and installation cost = $28.78

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	[illegible]	[illegible]5¢	50¢	55¢
Annual savings	$46.92	$52.78	$58.65	$64.52

Electric-powered pump

2.3 acre feet x 610 kWh per acre foot x $.04 per kWh = $56.12

Net savings: $56.12 electric savings - $24 timer and installation costs = $32.12

Dollars Saved at Various Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$42.09	$56.12	$70.15	$84.18

EXAMPLE OF ENERGY SAVINGS BY MAINTAINING IRRIGATION EQUIPMENT IN EFFICIENT CONDITION

$114.75 to $127.00 in energy savings year per 40-acre field

Keep irrigation equipment in good repair. Check gaskets in the sprinkler lines for leaks. Inspect your sprinkler nozzles. They enlarge after being used for a time and may apply water at a greater rate than the soil can accept it. Enlarged sprinkler nozzles also shorten the distance water is thrown, overload the pump, and cause a pressure drop that increases the droplet size. Investigate the efficiency of the well. Clogged perforations or water screens at the water bearing strata may prevent water flowing freely into the well.

Suppose that inefficiencies in the irrigation system due to lack of maintenance result in a 5-percent increase in the workload of the pump. On a 40-acre field using a medium power system (60 pounds per square inch) and a 200-foot lift delivering 30 acre inches per crop year, this can amount to over $100 per year.

Nonenergy Costs: Cost of materials used in maintenance may well exceed energy cost savings. However, other benefits will accrue in better water distribution and increased equipment life.

Calculations

Diesel-powered pump

2.5 acre feet x 51 gal of diesel per acre foot = 127.5 gal of diesel

127.5 gal of diesel x .05 energy loss x 40 acres x $.45 per gal of diesel = $114.75

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$102.00	$114.75	$127.50	$140.25

Electric-powered pump

2.5 acre feet x 610 kWh per acre foot = 1,525 kWh

1,525 kWh x .05 energy loss x 40 acres x $.04 per kWh = $127

Dollars Saved at Various Electrical Prices

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$91.50	$127.00	$152.50	$183.00

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EXAMPLE OF ENERGY SAVINGS BY IRRIGATION ACCORDING TO PLANT NEEDS	$194.50 to $209 in net energy savings	per year per 40-acre field

Ponding at the lower end of the field and water flowing along the roads is evidence of overwatering. Irrigate according to plant needs rather than following a set number of days on the calendar. You can improve irrigation efficiency by using aids such as soil augers, evaporation pans, and moisture meters. They help to accurately determine when and how much to apply. They are much better than trying to eyeball it. The results are reduced total water used in a season, reduced energy used for pumping, and increased money in your pocket.

Suppose that overwatering results in a 10-percent waste of water per year. Assume also a medium-power requirement of 60 pounds per square inch and a 200-foot lift on a side roll system covering 40 acres with 30 acre inches applied per year. The extra water pumped requires 12.75 gallons of diesel fuel or 152.5 kilowatt hours per acre. On a 40-acre field this could mean $230 or more a year in saved energy.

Nonenergy Costs: Cost of monitoring equipment ranges from $20 to $50. If it lasts more than one year, the net savings will be greater than shown in this example.

Calculations

Diesel-powered pump

0.25 acre foot x 51 gal of diesel per acre foot = 12.75 gal of diesel

12.75 gal of diesel x 40 acres x $.45 per gal of diesel = $229.50

Net savings: $229.50 diesel saving - $35 cost of monitoring equipment = $194.50

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$204.00	$229.50	$255.00	$280.50

Electric-powered pump

0.25 acre foot x 610 kWh per acre foot = 152.5 kWh

152.5 kWh x 40 acres x $.04 per kWh = $244

Net savings: $244 electric savings - $35 costs of monitoring equipment = $209

Dollars Saved at Various Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$183	$244	$305	$366

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Most livestock producers know how much their electricity and fuel bills have gone up during the last years, but few know how many kilowatt hours of electricity or gallons of diesel, gasoline, or LP gas they use or what they use it for. In evaluating the amount of energy used on the farm, look at the amount needed to perform different tasks. The recordkeeping charts in this section will help producers determine where and in what amounts they use energy.

Recording Energy Use

The following six recordkeeping tables will help a producer to keep track of total energy use by type and assign the right portion of it to livestock production. Energy Recordkeeper Number 1 is for electricity. If power for the livestock facilities goes through a separate meter, then the producer makes one entry in the livestock column of Energy Recordkeeper Number 1. If the electric power all goes through only one meter, the producer will have to estimate average kilowatts used following the suggestions in the footnotes to Energy Recordkeeper Number 1.

Energy Recordkeeper Number 2 is for LP or natural gas. If a producer uses LP and natural gas, he will have to use a separate sheet for each.

Energy Recordkeepers Number 3 and Number 4 are for tractor fuel. Energy Recordkeeper Number 3 is for the total tractor use and includes a column for hourly fuel use. Hourly fuel use can be an early warning that the tractor or equipment needs some attention. It also indicates the energy demands of different operations. Energy Recordkeeper Number 4 is for tractor time and fuel used in livestock production and uses information from Recordkeeper Number 3.

Energy Recordkeepers Number 5 and Number 6 are for truck and automobile fuel. These are set up to utilize odometer readings and to figure miles per gallon. Allocation of truck and auto use may be even more difficult than allocation of tractor hours. Approximate in instances where a detailed log of use is not maintained.

EXAMPLE OF ENERGY SAVINGS BY FEEDING FREE CHOICE CORN AND PROTEIN SUPPLEMENT VERSUS CUSTOM GROUND AND MIXED HOG FEED

$88 in energy savings in gasoline per year in fattening 300 feeder pigs

Many farmers buy 40-50 pound feeder pigs in the fall and winter after corn harvest time and feed them out to market weight. Some, especially those who feed only a few hundred hogs annually, haul their corn to commercial feed mills regularly to have it ground and mixed with protein supplement before feeding.

A farmer who feeds two successive lots of 150 pigs and who hauls feed 25 miles round trip for processing could save 800 miles of truck travel and 40 hours of driving time by feeding grain and supplement free choice. This amounts to saving $80 to $100 in gasoline cost alone. In addition, energy required by the commercial feed mill to grind and mix the feed would be saved. Consideration also should be given to improvement in feed efficiency from a complete processed ration. Differences in feed efficiency are not measured in this example.

Calculations

Each lot of 150 pigs eats an average of about 2.5 tons of feed per week for 16 weeks.

1 trip with a 2-ton truck to feed mill per week x 32 weeks per year x 25 miles per trip = 800 miles

800 miles at 5 miles per gal = 160 gal of gasoline.

Savings at Various Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Annual savings	$80	$88	$96	$104

Nonenergy Costs: Eliminate the trips to the feed mill and get rid of 6 to 7 cents per mile in nonfuel operating costs. Reduce wear on the truck. Avoid a custom processing charge ($5 per ton). Free 80-100 hours a year spent at the mill or enroute. A farmer may find he can operate with a small truck instead of a large one. Differences in feed efficiency and protein costs, if any, will have to be weighed along with these costs.

MANAGING RANGE AND HERD

Most cattle are grazed year round on pasture, range, or crop residues.

Cow-calf operators often use a pickup truck for supplemental feeding and checking on the herd. Regular tuneups help save fuel. Keeping the carburetor in proper adjustment also helps save fuel.

It costs about $55 a year for every 1,000 miles the farmer drives the pickup truck. This assumes 10 miles per gallon and gas at 55 cents per gallon.

Ranchers need to haul hay long distances especially in the West. Some have extended the beds of their farm trucks and added a section over the cab to increase bale capacity. Fuel use increases per load, but fuel and other costs per bale are reduced.

EXAMPLE OF ENERGY SAVINGS THROUGH CHANGING SUPPLEMENTAL FEEDING OF BEEF COWS

$170.50 to $293.92 in energy saved per year per 300-cow beef cattle herd

Much of the fossil fuel used in beef cattle production is used in getting supplemental feed to cattle on the range.

To save fuel, operators may limit range feeding to every other day, using salt to limit consumption of concentrates or using supplements designed for free choice feeding. If self-limiting dry concentrates are fed, the operators would have to invest in self-feeders, but the savings in fuel and labor would eventually offset this.

As an example, a 300-cow beef cattle operator in the Southwest High Plains of Texas may feed 1.56 pounds of 41 percent cottonseed cake per mature animal each day for 120 days this winter. This requires about 274 hours of pickup use. Since a 3/4-ton pickup can carry the 1,120 pounds of feed every other day almost as easily as the 560 pounds every day, the potential for savings in fuel is considerable.

Adding one-half pound of salt for each pound of meal results in the pickup being something less than half loaded. If the rancher changes his self feeders so that the feeders will hold a full pickup load, he can reduce his feeding trips from 120 to 50.

A 1.5-ton truck equipped with a tank could dispense enough liquid feed in four trips to supply the supplemental feed requirements of the breeding herd for 1 month, rather than making a trip out to feed every day. Each rancher must figure whether the differences in the cost of these feedstuffs will be offset by his fuel savings.

Calculations

Feed concentrates every day for 3 months: 2.28 hours per day x 120 days x 2.5 gal per hour = 685 gal

Feed every other day:
2.5 hours per day x 60 days x 2.5 gal per hour = 375 gal
Gasoline saved: 685 gal - 375 gal = 310 gal

Load self-feeders as required: 2.28 hours per load x 50 loads x 2.5 gal per hour = 285 gal
Gasoline saved: 685 gal - 285 gal = 400 gal

Feed liquid feed for 3 months:
5.02 hours per day x 12 days x 2.5 gal per hour = 150.6 gal
Gasoline saved: 685 gal - 157.6 gal = 534.4 gal

Gasoline Savings at Various Prices

Regular Bulk Delivery

Cents/gal	50¢	55¢	60¢	65¢
Annual savings (feeding every other day)	$155.00	$170.50	$186.00	$201.50
Annual savings (using self-feeders)	$200.00	$220.00	$240.00	$260.00
Annual savings (using liquid supplement)	$267.20	$293.92	$320.64	$347.36

EXAMPLE OF ENERGY SAVINGS FROM TWO GRAZING SYSTEMS

$245.00 to $493.35 in energy saved per year per 300-cow beef cattle herd

Yearlong grazing of livestock herds on the range is a common practice in the Southwest. Range can be improved by deferring use of particular pastures during the growing seasons. An additional benefit is savings in labor and pickup operating expenses associated with supplemental feeding. While a reduction in livestock numbers may be required at the outset to avoid overgrazing, stocking rates can be increased over time as range condition improves over the original grazing system.

Let's examine two types of deferred grazing to show the fuel savings. The first is a four-pasture deferred-rotation grazing system, and the second is the one-herd, high intensity, low frequency (HILF) grazing system.

A 300-cow beef cattle herd in the Southwest High Plains of Texas encompasses 8,928 acres. Pastures are sufficient in number and size to allow at least three dispersed sets of four-pasture deferred-rotation grazing systems. By concentrating the breeding herd into three pastures for shorter periods rather than in all pastures yearlong, pickup use in supplemental feeding, and livestock supervision and handling can be reduced considerably.

By opening adjoining pasture gates, the ranch can be combined into a 6-pasture operation for HILF grazing. The entire beef cow herd can be grazed in each pasture for 4 weeks before moving them to the next pasture, thus providing periods of deferment. This offers an opportunity to feed cattle supplementally during the winter and to oversee them in one pasture at a time. Pickup fuel used in distributing feed and in supervising and handling cattle can be reduced significantly.

<u>Calculations</u>

<u>Herd dispersed over entire ranch</u>:

Feeding: 2.28 hours per day x 120 days x 2.5 gal per hour = 685 gal of gasoline

Supervision and handling: 1.22 hours per day x 365 days x 2.5 gal per hour = 1,112 gal of gasoline

Total gal of gasoline: 685 gal + 1,112 gal = 1,797 gal

<u>Four-pasture deferred-rotation grazing system</u>:

Feeding: 1.71 hours per day x 120 days x 2.5 gal of gasoline per hour = 512 gal of gasoline

Supervision and handling: .92 hours per day x 365 days x 2.5 gal per hour = 840 gal of gasoline

Total gal of gasoline: 512 gal + 840 gal = 1,352

Gasoline saved: 1,797 - 1,352 = 445 gal

<u>HILF grazing system</u>:

Feeding: 1.14 hours per day x 120 days x 2.5 gal per hour = 342 gal of gasoline

Supervision and handling: .61 hours per day x 365 days x 2.5 gal per hour = 558 gal of gasoline

Total gal of gasoline: 342 gal + 558 gal = 900 gal of gasoline

Gasoline saved: 1,797 gal - 900 gal = 897 gal

(continued on page 23)

Gasoline Savings at Various Prices

Regular Bulk Delivery

Cents/gal	50¢	55¢	60¢	65¢
Four-Pasture Deferred Rotation Grazing System				
Annual savings	$222.50	$244.75	$267.00	$289.25
HILF Grazing System				
Annual savings	$448.50	$493.35	$538.20	$583.05

Nonenergy Costs: If fencing is already adequate, fuel savings are a net gain. In addition, the four-pasture system saves $124 in truck repairs and lubrication plus $400 in labor at $2.25 per hour. HILF saves $250 in truck costs; $809 in labor at $2.25 an hour.

EXAMPLE OF ENERGY SAVINGS BY CHANGING TO A LOW-VOLUME APPLICATION OF HERBICIDES TO CONTROL BRUSH

$1,357.06 in energy saved per year	per 300-cow beef cattle herd

Brush and other noxious plants compete for water, soil nutrients, light, and space with range and pasture forage plants. Heavy infestations of brush, such as mesquite, white brush, and scrub oak have reduced range-carrying capacities to the point that ranch operators must control brush or reduce stocking rates. Aerial applications of herbicides are used. The material usually is mixed with diesel oil or diesel oil and other carriers such as water. This practice of using carriers extends the herbicide more uniformly over the treatment area and facilitates adherence of the herbicide to plant leaves for increased effectiveness.

A 300-cow beef cattle ranch in Southwest Texas has a mesquite infestation. Part of the ranch is sprayed each year. Deferment of grazing usually follows brush control treatment, so one pasture may be treated and rested before another one is treated. The rancher would spray 744 acres, one of his 12 pastures, each year. Experiments show that the amount of carrier can be reduced from 5 gallons per acre to 1 gallon per acre without reducing the coverage or the effectiveness in brush kill appreciably. Reducing diesel oil used as a carrier saves both diesel oil and flight fuel used in herbicide application. While this is a custom operation, the savings here are reflected in the custom rate charged.

Calculations

Spray mesquite with full carrier:

5 gal diesel oil per acre x 744 acres = 3,720 gal of diesel

.14 gal aviation gasoline per acre x 744 acres = 104.16 gal

Spray mesquite with low-volume carrier:

1 gal diesel oil per acre x 744 acres = 744 gal of diesel

.10 gal of aviation gasoline per acre x 744 acres = 74.4 gal of gasoline

Fuel saved: 3,720 gal of diesel - 744 gal of diesel = 2,976 gal of diesel

104.16 gal of gasoline - 74.4 gal of gasoline = 29.76 gal of gasoline

Energy Savings at Various Prices

	Diesel Fuel			
Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$1,190.40	$1,339.20	$1,488.00	$1,636.80
	Aviation Fuel			
Cents/gal	55¢	60¢	65¢	70¢
Annual savings	$16.37	$17.86	$19.34	$20.83
Total annual savings	$1,206.77	$1,357.06	$1,507.34	$1,657.63

VENTILATING AND HEATING

In most beef cattle and sheep operations, little or no mechanical ventilation or supplemental heat is required. But in some of the new confined housing systems the energy requirement is high. Heating and ventilation are large energy users in confinement hog production, especially for farrowing houses and nursery buildings. The electrical power needed to ventilate a total confinement farrow-to-finish hog facility producing 1,600 head a year in the central Corn Belt is about 55,000 kilowatt-hours a year. Heating for the farrowing house and nursery building requires about 2,100 gallons of LP gas plus 3,700 kilowatt-hours of electricity to operate heater fans and heat lamps.

Operation

Ventilation of a livestock building helps to remove both heat and moisture. During the summer, heat removal is the major concern. In the winter, moisture removal takes precedence. Because of heat loss through the walls and roof and cold incoming fresh air, supplemental heat may be needed. This causes condensation to form in the building. Insulation reduces heat loss and thus will reduce supplemental heat needs. A general rule: If you ventilate, insulate.

Fans used in livestock buildings are rated by the cubic feet of air they move per minute. Most are run by electric motors, and many have two or more speeds. Fans should be operated only when necessary. Ventilating fans usually are controlled by a thermostat which turns on the fans whenever the barn temperature goes above a set level.

Maintenance

Electric fan motors should be checked and oiled regularly. They are probably run more hours than any other electric motor and receive less attention. Cleaning off dust and oil that builds up on the fan blades will save 5 to 10 percent on energy in winter months, and help fans move more air in the summer months. Cleaning of the louvers to make them operate more smoothly and accurately will improve a fan's efficiency.

Supplemental heat may be provided by gas or electric heaters. Fired heaters need routine checkups, just like any furnace. Turning off the whole system, pilot light included, will save energy in the summer. In damp locations consider possible corrosive effects of leaving the pilot light off for extended periods. Cleaning of filters and air vents will improve the heating unit's efficiency. Resistance electrical heating is usually more expensive than fired heating for large areas.

Planning

Planning a new facility? Look carefully at the ventilation and supplemental heating needs. Warm confinement barns may provide a better environment for feeder cattle than cold barns. However, the cost of power to ventilate and heat will more than offset any advantage of warm confinement. Hogs benefit greatly from proper control of temperature and ventilation. Both heating and ventilation should be top priority items in planning a hog production facility.

If a new facility includes ventilation by variable speed fans, check to make sure the fan is controlled by a solid controller rather than a straight resistant unit. The motor controlled by a straight resistant unit wastes energy at low speed.

Insulation

The tabulation on page 27 provides information on the insulating value of various material.

An R-value of 12-14 is recommended for the walls and 16 or more for the ceiling.

The R-value of a material is a measure of its capacity to resist heat flow. Figure 3 and the tabulation on page 27 present 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. The vapor barrier should allow less than 1/2 perm of moisture vapor to pass through the material. (A perm is the amount of moisture vapor in grains that will pass through a square foot of material in 1 hour when the pressure difference is 1 inch of mercury.)

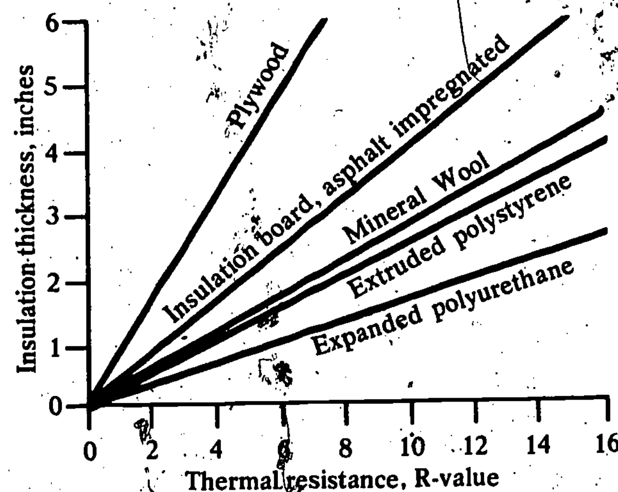

Figure 3. RELATIONSHIP BETWEEN THERMAL RESISTANCE, R-VALUE, AND THICKNESS OF INSULATION FOR CERTAIN MATERIALS*

* Carr, Lewis E., Kenneth E. Felton, and James L. Nicholson, Planning for Fuel Conservation in Your Broiler House, MEP-320, p. 12, Cooperative Extension Service, Univ. of Maryland, College Park, MD., 1974.

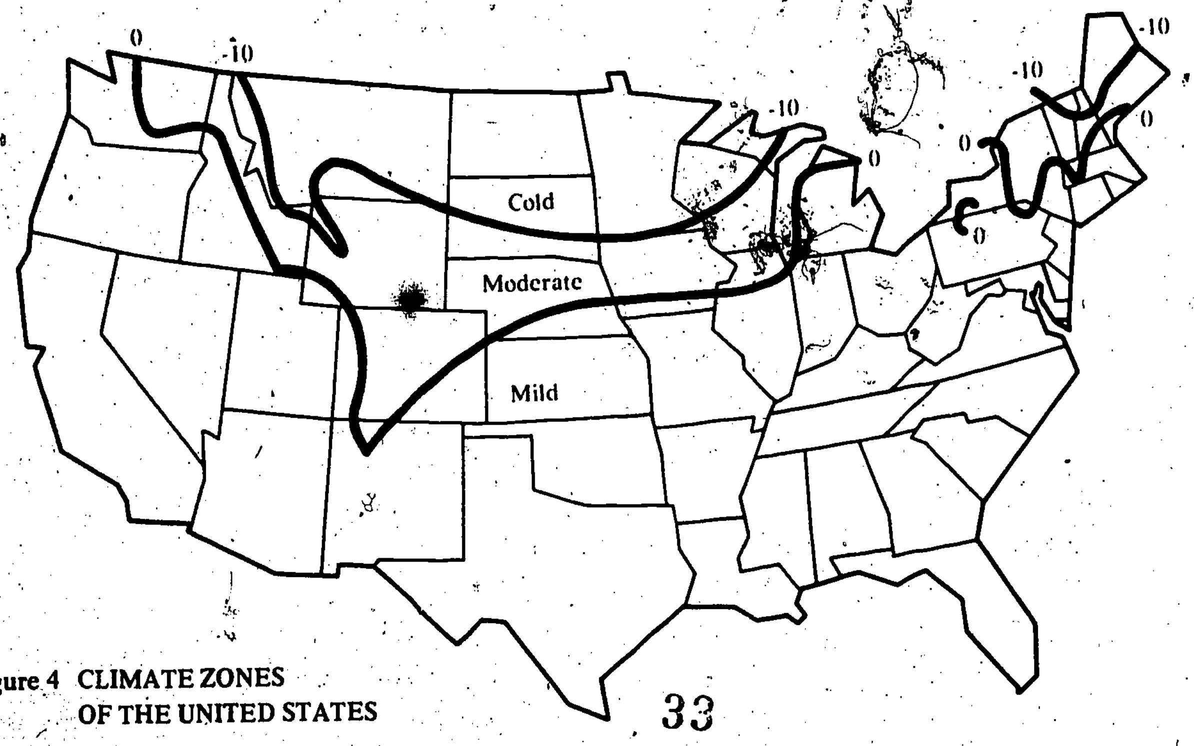

Figure 4 CLIMATE ZONES OF THE UNITED STATES

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Insulation Value of Materials

Material	Thickness (inches)	Resistance rating (R)
Air space, enclosed by ordinary materials	3/4 - 4	0.91
Air space, aluminum foil one side	3/4 - 4	2.17
Air space, aluminum foil both sides	3/4 - 4	2.44
Surface film, inside, nonreflective (gen. val.)		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
Hardboard	1/8	0.09
Insulation board, sheathing regular density	1/2	1.32
Blanket insulation, mineral (rock) wool, or glass	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 extruded plain	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, lightweight	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	3/4	0.79
Bevel siding 1/2 x 8	3/4	0.81
Bevel siding 3/4 x 10		1.05
Building paper		0.06
Roll roofing, asphalt		0.15
Built-up 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
Polyethylene vapor barrier		Negligible
Rolled side wall curtain		Negligible

Source: Carr, Lewis E., Kenneth E. Felton, and James L. Nicholson, Planning for Fuel Conservation in Your Broiler House, Coop. Ext. Serv., Univ. of Md., College Park, Md., 1974, MEP-302, pp. 21-22. Compiled from ASRAE Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc. 1972 ed., pp. 357-364. Jennings, Burgess H. and Samuel R. Lewis, Air Conditioning and Refrigeration, 4th ed., 2nd printing 1959, International Textbook Co., Scranton, Pa., pp. 91-108, 152-153.

EXAMPLE OF ENERGY SAVINGS BY SHUTTING OFF PILOT LIGHT ON SPACE HEATER

The pilot light on your space heater burns 5 or more gallons of LP gas per month. This energy is not wasted in the winter months when you need the heat, but it is in the summer.

The whole system can be turned off by shutting off the valve between the storage tank and the gas line leading to your space heater.

One farmer reported a monthly LP gas bill of $5 to $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.

$14.00 in energy saving per summer season

<u>Calculations</u>

5 gal of LP gas/month x 7 months = 35 gal of LP gas

35 gal of LP gas x $.40/gal = $14

<u>Dollars Saved at Various LP Gas Prices</u>

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$12.45	$14.00	$15.75	$17.50

EXAMPLE OF ENERGY SAVINGS BY INSULATING A FARROWING HOUSE

$1,276 in energy savings through proper insulation	versus no insulation of a 40-crate farrowing house in Illinois

Insulation will keep a farrowing house warmer in winter and cooler in summer. This will cut supplemental heating needs and reduce ventilation requirements.

Adding insulation to existing walls is difficult, and in some cases impossible. In new buildings adequate insulation should be put into the walls. Insulation to an "R" value of 12 to 14 is recommended. Storm windows or plastic covers on windows will approximately halve the heat loss through windows. Seal cracks around windows and doors for added protection. The ceiling of existing buildings can usually be insulated with little difficulty. The ceiling should be insulated to an "R" value of 16 or more.

In most buildings the floors are of concrete slab, and no insulation can be added. When building a new structure, use crushed rock or other substance that will add dead air space below your floors to act as insulation.

A 40-crate (26 x 120 feet) uninsulated farrowing house will require nearly twice as much heating and cooling as one that is properly insulated. In Illinois, the heating of an uninslated farrowing house would consume about 2,400 gallons of LP gas during a typical winter season and as many as 5,800 kilowatt-hours of electricity for heating. Adequate ventilation could take as much as 34,000 kilowatt-hours. Proper insulation could cut the amount of gas and electricity needed in half.

The cost involved in insulation is substantial. It can be a dollar or more per square foot of floor space.

<u>Calculations</u>

2,400 gal of LP gas x .5 saved = 1,200 gal LP gas saved

5,800 kWh x .5 saved = 2,900 kWh saved

3,400 kWh x .5 saved = 17,000 kWh saved

2,900 kWh saved + 17,000 kWh saved = 19,900 kWh saved

1,200 gal of LP gas saved x $.40 per gal = $480

19,900 kWh saved x $.04 per kWh = $796

<u>Energy Savings at Various Prices</u>

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$597	$796	$995	$1,194

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$420	$480	$540	$600
Total annual savings	$1,017	$1,276	$1,535	$1,794

Nonenergy Costs: One has to buy adequate insulation. It will cost $3,000 to $3,500 to do the job for a 40-crate farrowing house. Annual overhead cost will be $468 to $570 if you assume a 10-year life and 10 percent interest—a net cost advantage of $706 to $808 per year for proper insulation. An added benefit is more effective summer ventilation.

EXAMPLE OF ENERGY SAVINGS IN COLD VERSUS WARM CONFINEMENT BARNS FOR CATTLE FEEDING

$1,217.52 in energy savings for a cold versus a warm confinement barn with capacity for 200 feeder cattle

Total confinement has some advantages over feeding beef cattle in shed-and-lot or open-lot system. Warm barns are fully enclosed with most of the ventilation provided by fans. Cold confinement barns are full roofed, but are open on the sides except for drop curtains to shield cattle from the wind. Ventilation fans are not necessary in cold barns. Animals do better in warm barns.

However, gains are not enough to offset the added cost of the warm building, especially the power required for ventilation. Winter ventilation requires air movement of at least 15 cubic feet per minute per animal while summer ventilation needs are a minimum of 1,200 cubic feet per minute per animal plus pit fans. With a 200-head warm confinement cattle barn, ventilation requirements will average about 30,000 cubic feet per minute for the year.

Fans differ as to the amount of air they will move, but for estimating purposes a 1.0 horsepower fan operating at 0.1 inches of static pressure can be credited with 20,000 cubic feet per minute. Thus, the equivalent of a 1.5 horsepower fan would be needed year-round for a 200-head warm confinement barn. That translates into 13,140 horsepower hours or 24,178 kilowatt hours--more if thermostat-controlled motors are used during winter when less air movement is needed.

Supplemental heat is needed to maintain condensation control at temperatures below 10°F, if indoor conditions are to be maintained above 35°F. Supplying the recommended 400 British thermal unit per hour per animal for 30 days in a moderate climate would take 626 gallons of LP gas.

Calculations

Cost to heat a warm barn:

400 Btu/hr x 24 hr x 30 days x 200 head = 57.6 million Btu ÷ 92,000 Btu = 626 gal LP gas. 626 gal LP gas x $.40 = $250.40.

Cost to ventilate a warm barn:

Average air movement per animal = 150 cubic feet per minute

200 head x 150 cubic feet per minute per head = 30,000 cubic feet per minute

Output of 1.0 hp fan = 20,000 cubic feet per minute

1.5 hp x 365 days x 24 hours = 13,140 horsepower hours

13,140 hp hours x 1.84 kWh per hp = 24,178 kWh

24,178 kWh x $0.04 per kWh = $967.12

Cost to heat and ventilate a cold barn:

none

Energy Savings at Various Prices

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$219.10	$250.40	$281.70	$313.00

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$725.34	$967.12	$1,208.90	$1,450.68

Total annual savings	$944.44	$1,217.52	$1,490.60	$1,763.68

Nonenergy Costs: A cold confinement barn for 200 feeder cattle will cost about $10,000 less than a warm barn. Annual costs for the cold barn are $1,500 less than for the warm barn in addition to reduced energy costs.

Source: Beef Housing and Equipment Handbook, MWFS-6, Midwest Plan Service, Iowa State Univ., Ames, Iowa, 1968, p. 9.

Example of energy saving: Relamping opportunities
(All costs are figures at 4 cents per kilowatt-hour.
The annual savings include normal ballast loss.)

Area	Relamp from	To	To save annually	Approximate investment necessary
12 hours daily use				
Night light	2 300-watt incandescent floodlights	1 250-watt mercury vapor	$59.96	$115 to $130
6 hours daily use				
Outside lighting	1 200-watt incandescent	1 100-watt mercury vapor	$7.96	$50 to $70
3 hours daily use				
Farrowing house (20 crate)	8 100-watt incandescent	4 40-watt fluorescent	$25.68	$40 to $48
2 hours daily use				
Nursery ($1,000\ ft^2$)	6 100-watt incandescent	3 40-watt fluorescent	$12.84	$30 to $36
Hog barn ($3,000\ ft^2$)	16 100-watt incandescent	8 40-watt fluorescent	$34.24	$80 to $96
Feed house ($1,000\ ft^2$)	1 100-watt incandescent	1 20-watt fluorescent	$2.20	$8 to $10
1 hour daily use				
Cattle shed ($3,000\ ft^2$)	6 100-watt incandescent	3 40-watt fluorescent	$6.42	$30 to $36
Hay shed ($3,000\ ft^2$)	3 150-watt incandescent	1 175-watt mercury vapor	$3.85	$65 to $80
Shop	4 100-watt incandescent	2 40-watt fluorescent	$4.28	$20 to $24

Note: Some of the relampings are not economical at current prices. These were included to give information that can be used in planning for the needs of future building or remodelings. Also, the life of fluorescent and mercury and sodium vapor lamps is much longer than incandescent lamps. However, fluorescents do not work well in cold barns.

LIGHTING

Try to cut lighting costs by a fourth. While they are a small part of a livestock producer's total electric bill, the savings can be worth the effort. A 150-watt bulb left on overnight (12 hours) consumes 1.8 kilowatt hours, and this adds up to several hundred kilowatt hours or $20 to $30 in a year.

Use the lowest possible bulb wattage. Clean light fixtures, and eliminate unnecessary lights to reduce lighting bills. Inside, fluorescent bulbs provide four times the light of incandescent bulbs. Outside, where possible, use a mercury vapor lamp to provide twice as much light as an incandescent lamp per unit of energy used. Substitution of one 100-watt incandescent bulb for two 60-watt bulbs generates a 16 percent energy saving and provides approximately the same number of lumens.

Units used to measure lighting are lumens, watts, foot candles, and hours. The light output of a bulb is measured in lumens, and the amount of electricity consumed in watts. A foot candle indicates the lumens that fall on 1 square foot of surface. The life span of a bulb is measured in hours. Some of this information is printed on the light bulb package. A comparative reading of these packages may reveal that one kind of bulb has a longer life than a "soft" or tinted incandescent bulb of the same wattage.

Table 5--Comparison of characteristics of lamps

Type of lamp	Size by watts	Average output in lumens	Average hours of life	Average lumens per watt 1/
Incandescent (standard)	25	225		9
	40	430		11
	60	810	750	14
	100	1,600	to	16
	150	2,500	1,000 2/	17
	200	3,500		18
	300	5,490		18
Fluorescent (standard)	15	660		34
	20	1,000	18,000	40
	40	3,200		60
Mercury (clear)	75	2,800		
	100	3,800		
	175	7,500	24,000	40
	250	11,600		45
	400	21,000		50
	700	39,000		
Metal halide	175	12,000		
	400	34,000	15,000	75
	1,000	95,000		
Sodium (high-pressure)	250	25,500		
	400	47,000	16,000	100
	1,000	130,000		

1/ Includes ballast requirements, if necessary; rating not available for all size and types of lamps.

2/ Longer life lamps (up to 3,500 hours) are available at a high initial cost. They produce 10-15 percent fewer lumens per watt.

Source: Campbell, Lowell and Henry M. Cathey, "Outdoor Lighting Has Many Roles," 1973 Yearbook Agriculture, USDA Yearbook Separate No. 3854 p. 190.

Before changing lighting, walk around facilities, both indoors and outdoors. Note the areas which appear over- or under-lighted. An individual evaluation of the amount of light needed may be adequate. To be more accurate, use a light meter. With the aid of a simple light meter and the tabulation below, you can match the amount of light provided to specific tasks to be performed.

Two simple rules will help one to use a light meter and the above tabulation more effectively.

1. To obtain an accurate measure, hold the light meter 30 inches away from a wall and 30 inches from the floor.

2. Also, try to determine the age of the bulbs in each area. If they are old, their light will be weak and give an inaccurate indication of the lighting level when new bulbs are installed.

Recommended Illumination Levels

Area or visual task	Foot candles
Feeding, inspection, and cleaning	20
Reading charts and records	30
Close inspection of animals	50
Washing and sanitizing 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

Source: Krewatch, Albert V., "Farm Lighting," Farmers Bulletin 2243, USDA, Dec. 1969, pp. 10-12.

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EXAMPLE OF ENERGY SAVINGS BY CAREFUL ATTENTION TO LIGHTING USE *

One farmer reported a savings of 400 kilowatt hours on his electrical bill when his hired man quit and he had to hire a different one. Apparently, the first hired man had a hard time remembering to turn off the lights. This 400-kilowatt hour decrease may seem like an unduly large amount, but when it is broken down to the amount of 100-watt bulbs that would have to be on continuously, it is not unreasonable. Just six 100-watt bulbs being used continuously would consume 5,256 kilowatt hours in a year.

*See other examples of lighting conservation on page 32.

$210.24 in energy savings per year by careful attention to lighting

Calculations

100 watts x 24 hours per day x 6 bulbs = 14,400 watt-hours per day

14,400 watt-hours per day x 365 days ÷ 1,000 watts = 5,256 kW

5,256 kW x $.04 kWh = $210.24 per year

Energy Savings at Various Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$157.68	$210.24	$262.80	$315.36

SAVING ENERGY IN LIVESTOCK OPERATIONS

DRYING GRAIN

Corn harvest usually begins when grain moisture is 28 to 30 percent. By the end of the harvest season the moisture of corn in the field is usually around 18 percent. Harvested corn usually averages 23 percent moisture content.

Corn to be sold at harvest must be dried to 15.5 percent moisture or sold at a discount. To be stored on the farm, it is normally dried to 13 to 15.5 percent moisture depending upon how long it is to be stored. Usually, 8 to 10 percentage points of moisture are removed from corn during the drying process.

Grain drying is too complex a process and done in too many ways to make a thorough set of recommendations here. Nevertheless, a few examples to show the possibilities for energy savings follow.

EXAMPLE OF SAVING ENERGY THROUGH THE FEEDING OF HIGH MOISTURE CORN 2/

$47.57 to $522.11 net energy savings from feeding high moisture corn versus high temperature drying

A farmer harvests, dries, and feeds 20,000 bushels of No. 2 corn each year to finish 350 steer calves to slaughter weight or produce 200 litters of hogs in a farrow-to-finish operation. If he removes 9.5 points of moisture, from 25 to 15.5 percent moisture, he starts with about 22,660 bushels of wet corn.

If he uses a batch-in-bin drying system, he has $24,850 invested in equipment with an annual cost of $2,955 for this fixed investment. The operating costs for this system are $2,753 of which LP gas is $1,507 (0.0175 gallon of LP per point of moisture removed at $.40 per gallon of LP) and $227 is for electricity (.15 kilowatt hour of electricity per bushel for the dryer and .1 kilowatt hour per bushel for aeration during storage). The total annual costs of No. 2 corn for this system is $.285 per bushel.

As long as the corn is going to be fed to cattle or hogs, drying is not the only preserving method one can use. High moisture corn can be placed in an air-tight storage structure and preserved through fermentation. Propionic acid allows preservation of high moisture corn without fermentation. The animals will gain the same no matter which preserving method is used.

For an oxygen-free corn storage system using a 25 by 65-foot upright silo, the investment costs are $38,610 for equipment with an annual cost of $4,184 for this fixed investment. The operating costs are $1,476 of which diesel fuel is $70 to operate the tractor-powered blower for 45.7 hours. The total annual costs per bushel equivalent of No. 2 corn for this system is $.283. Cost of the two systems are essentially the same, but drying takes $1,734 of the energy annually; the high moisture system, $70. A price for propionic acid of $.36 per pound makes acid treating of corn much more expensive than drying or fermenting the corn. However, acid treating can be used with many existing storage structures on farms and may be justifiable under some conditions such as a shortage of gas. Also acid-treated corn may be sold to another farmer for feeding more easily than fermented corn.

A farmer can reduce energy use by feeding high moisture corn. However, he may reduce flexibility in marketing his crop, may create complications in ration formulation, and may precipitate changes in methods of feeding. Weigh the options carefully before making a change.

(continued on page 38)

2/ Material for this example was provided by Julius Edwards from his Master's thesis, "Economics of Energy Use Under Selected Alternative Technologies for Illinois Hog Production," Univ. of Illinois.

Calculations

High temperature drying:

25 percent beginning moisture corn - 15.5 percent ending moisture corn = 9.5 percentage points of moisture removed.

9.5 percentage points of moisture removed x 0.0175 gal of LP gas per percentage point of moisture removed x 22,660 bu of 25 percent corn = 3,767.225 gal of LP gas.

3,767.225 gal of LP gas x $.40 per gal of LP = $1,506.89.

(0.15 kWh of electricity for dryer + 0.1 kWh of electricity for aeration) x 22,660 bu of 25 percent corn = 5,665 kWh.

5,665 kWh x $.04 per kWh = $226.60

Oxygen-free storage

45.7 hours needed to fill silo x 3.4 gal of diesel consumed by a 50-hp tractor operating at full power = 155.38 gal of diesel.

155.38 gal of diesel x $.45 per gal = $69.92.

Costs and Savings at Various Energy Prices

High-Temperature Drying

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Costs	$1,318.53	$1,506.89	$1,695.25	$1,883.61

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Costs	$ 169.95	$ 226.00	$ 283.25	$ 339.90
Annual drying costs	$5,462.48	$5,707.49	$5,992.50	$6,197.57

Oxygen-Free Storage

Diesel Fuel

Cents/gal	40¢	45¢	50¢	55¢
Costs	$ 62.15	$ 69.92	$ 77.69	$ 85.46
Annual oxygen-free storage costs	$5,652.15	$5,659.92	$5,667.69	$5,675.46
Net savings--drying versus oxygen-free storage	-$ 189.67	$ 47.57	$ 284.81	$ 522.11

EXAMPLE OF SAVING ENERGY THROUGH BETTER PLANNING OF THE CORN HARVEST PROGRAM

Corn that has matured can be handled by modern combines when the moisture level is as high as 30 percent, but kernel breakage is high and harvesting losses are increased. One might profitably delay harvest a few days. During the early fall, temperatures are usually rather high. The rate of field drying is also high. Delaying harvest for a week or 10 days may mean harvesting 25 instead of 30-percent moisture corn. With a relatively small crop, most producers can wait awhile and still get the crop into storage well before bad weather and the high loss period that occurs later in the year. Even a 2-row corn combine can harvest 20,000 bushels of corn from land yielding 100 bushels per acre in just about twelve 10-hour days.

Most of the corn on a farm will be harvested at the same moisture content. Waiting a week or 10 days, however, can well mean that the first 5,000 bushels comes in at an average of 23 instead of 28 percent moisture. It takes about 1.75 gallons of LP gas and 1.50 kilowatts of electricity to remove one point of moisture from 100 bushels of corn in a high-temperature drying system. Letting 5,000 bushels of corn field dry an extra 5 percentage points can thus save you about 438 gallons of LP gas and 360 kilowatts of electricity. Also, the dryer corn will combine with less damage and loss, and it will contain less trash and fines thereby reducing problems in storage.

$190.20 in energy savings per year by delaying corn harvest and letting	5,000 bushels of corn field dry another 5 percentage points

Calculations

5 points x 5,000 bu x 1.75 gal of LP gas = 438 gal

5 points x 5,000 bu x 1.50 kWh = 375 kWh

Energy Savings at Various Fuel Prices

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$11.25	$15.00	$18.75	$22.50

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$153.30	$175.20	$197.10	$219.00
Total savings	$164.55	$190.20	$215.85	$241.50

EXAMPLE OF SAVING ENERGY THROUGH SELECTING THE RIGHT SIZE OF STORAGE BINS FOR CORN

$386 in net energy savings per year by varying ending moisture levels and storing 20,000 bushels of corn in three bins instead of one.

A 20,000 bushel bin plus perforated floor and aeration fan presently costs about $12,000. Three 6,670 bushel bins similarly equipped cost about $15,000 or $3,000 more.

The initial cost savings provide a strong incentive for building large grain bins, but they may cost more than smaller bins in extra drying costs. Corn to be stored through the hot summer months must be dried to 13 or 14 percent moisture, or it may not keep.

Corn can be stored satisfactorily at much higher moisture levels without either spoiling or fermenting if it can be kept cool. For example, corn containing 20 percent moisture can be kept in storage about 60 days if it can be cooled quickly to 45°F. This is easy to accomplish with night air in the latter part of the harvest season in the Corn Belt. The bin containing cool, high moisture corn can then be fed out before warm weather comes.

Several small bins rather than one large bin provide the flexibility to vary moisture content of corn according to use periods. Drying 20,000 bushels of No. 2 corn equivalent from an average harvest moisture of 23.5 percent (22,200 bushels of wet corn) to 14 percent moisture for year-round storage takes about 3,691 gallons of LP gas and 3,164 killowatt hours of electricity.

Suppose instead one uses three 6,670 bushel bins. Early harvest corn averaging 25 percent moisture is dried to 14 percent and put in one bin for summer feeding. Mid-harvest corn averaging 23 percent is dried to 18 percent, cooled as the season progresses, and kept for feeding in the spring. Late harvest corn averaging 20 percent moisture is put in the third bin directly from the combine, cooled with natural air and fed during the winter. Aeration is necessary for all corn regardless of moisture or bin size.

The three-bin system results in an annual savings of about $806 for drying--1,856 gallons of LP gas and 1,591 kilowatts of electricity. The annual cost of the $3,000 additional investment in smaller bins at 14 percent is $420. Net gain for the flexible system is about $386 a year.

Calculations

One-bin system:

20,000 bu of No. 2 corn = 22,200 bu of 23.5 percent corn

Average beginning moisture - 23.5 percent

Average ending moisture - 14.0 percent

Moisture removed: 23.5 to 14.0 = 9.5 points

9.5 points x 22,200 bu x 1.75 gal LP per hundred bu per point = 3,691 gal LP

9.5 points x 22,200 bu x 1.50 kWh per hundred bu per point = 3,164 kWh

Three-bin system:

Summer: 6,670 bu No. 2 corn = 7,560 bu of 25 percent corn

Spring: 6,670 bu No. 2 corn = 7,360 bu of 23 percent corn

Winter: 6,670 bu No. 2 corn = 7,080 bu of 20 percent corn

Summer: 25-14 = 9 points (moisture)

9 points x 75.6 hundred bu x 1.75 gal of LP per hundred bu per point = 1,191 gal LP

9 points x 75.6 hundred bu x 1.50 kWh per hundred bu per point = 1,021 kWh

Spring: 23-18 = 5 points (moisture)

5 points x 73.6 hundred bu x 1.75 gal LP per hundred bushel per point = 644 gal LP

5 points x 73.6 hundred bu x 1.50 kWh per hundred bushels per point = 552 kWh

Winter: No drying

Total energy use: 1,835 gal LP gas and 1,573 kWh electricity

Difference: 1,856 gal LP gas and 1,591 kWh of electricity

Added investment cost: $3,000 additional for smaller bins x .14 investment cost = $420

Energy savings: $806.04 - $420 = $386.04 per year

Dollars Saved at Various Fuel Prices

LP Gas

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$649.60	$742.40	$835.20	$928.00

Electricity

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$47.73	$63.64	$79.55	$95.46
Total savings	$697.33	$806.04	$914.75	$1,023.46

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IRRIGATING WITH SPRINKLERS

Energy demands for sprinkler irrigation can be high. Because of the availability of water, either because of a permit allocation or its relatively low cost, irrigators may not always employ the best water management techniques. Many times too much water goes on a field only to run off or evaporate. Excess water pumping may be more expensive than many irrigators realize. Irrigate strictly according to crop and soil needs to reduce annual water application and energy cost substantially without lower yields. High yields of pasture and hay crops require supplemental irrigation throughout much of the Western half of the United States.

Table 6--Diesel fuel required per acre for 1 foot of water applied at various pressures 1/

Lift (feet)	20 psi	40 psi	60 psi	80 psi	100 psi
	Gallons				
50	15	22	28	35	42
100	22	29	36	43	50
200	37	44	51	58	65
300	52	59	66	73	80
400	68	74	81	88	95
500	83	90	96	104	111

1/ One gallon of diesel fuel produces about the same work as 1.4 gallons of gasoline.

Source: Energy Facts and Figures, EM-3943, Washington State Univ., Pullman, Wash., Aug. 1975.

Table 7--Kilowatt-hours per acre-foot of water applied at various pressures

Lift (feet)	20 psi	40 psi	60 psi	80 psi	100 psi
	Kilowatt-hours				
50	192	260	350	440	510
100	280	350	440	525	600
200	455	525	610	700	790
300	630	700	790	875	950
400	800	875	960	1,050	1,120
500	980	1,050	1,140	1,230	1,290

Source: Energy Facts and Figures, EM-3943, Washington State Univ., Pullman, Wash., Aug. 1975

EXAMPLE OF ENERGY SAVINGS BY USE OF AUTOMATIC TIMERS ON IRRIGATION PUMPS

$28.78 to $32.12 in net energy savings per year

Installation of timers to automatically switch off pumps can result in considerable energy savings. Not only does a timer eliminate the need to get up and turn off a pump during the inconvenient nighttime hours, but it also decreases overapplication of water which can result in plant and soil damage, and wasted energy use.

Consider a situation where the pumps run unnecessarily 25 hours a year because there is no one to attend the cut off switches. On a medium pressure well (60 pounds per square inch) and a 200-foot lift with a system delivering 500 gallons per minute, $53 in energy savings could be realized annually with a diesel pump; $56 with an electric pump.

The cost of automatic timers ranges from $9 to $31 plus installation costs of $3 to $5.

<u>Calculations</u>

<u>Diesel-powered pump</u>

25 hours x 60 minutes per hour x 500 gal per minute ÷ 326,000 gal per acre foot = 2.3 acre feet

2.3 acre feet x 51 gal of diesel per acre foot x $.45 per gal of diesel = $52.78

Net savings: $52.78 fuel savings - $24 timer and installation cost = $28.78

<u>Dollars Saved at Various Diesel Fuel Prices</u>

Cents/gal	[illegible]	45¢	50¢	55¢
Annual savings	$46.92	$52.78	$58.65	$64.52

<u>Electric-powered pump</u>

2.3 acre feet x 610 kWh per acre foot x $.04 per kWh = $56.12

Net savings: $56.12 electric savings - $24 timer and installation costs = $32.12

<u>Dollars Saved at Various Electrical Rates</u>

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$42.09	$56.12	$70.15	$84.18

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EXAMPLE OF ENERGY SAVINGS BY MAINTAINING IRRIGATION EQUIPMENT IN EFFICIENT CONDITION

$114.75 to $127.00 in energy savings year per 40-acre field

Keep irrigation equipment in good repair. Check gaskets in the sprinkler lines for leaks. Inspect your sprinkler nozzles. They enlarge after being used for a time and may apply water at a greater rate than the soil can accept it. Enlarged sprinkler nozzles also shorten the distance water is thrown, overload the pump, and cause a pressure drop that increases the droplet size. Investigate the efficiency of the well. Clogged perforations or water screens at the water bearing strata may prevent water flowing freely into the well.

Suppose that inefficiencies in the irrigation system due to lack of maintenance result in a 5-percent increase in the workload of the pump. On a 40-acre field using a medium power system (60 pounds per square inch) and a 200-foot lift delivering 30 acre inches per crop year, this can amount to over $100 per year.

Nonenergy Costs: Cost of materials used in maintenance may well exceed energy cost savings. However, other benefits will accrue in better water distribution and increased equipment life.

Calculations

Diesel-powered pump

2.5 acre feet x 51 gal of diesel per acre foot = 127.5 gal of diesel

127.5 gal of diesel x .05 energy loss x 40 acres x $.45 per gal of diesel = $114.75

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$102.00	$114.75	$127.50	$140.25

Electric-powered pump

2.5 acre feet x 610 kWh per acre foot = 1,525 kWh

1,525 kWh x .05 energy loss x 40 acres x $.04 per kWh = $127

Dollars Saved at Various Electrical Prices

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$91.50	$127.00	$152.50	$183.00

EXAMPLE OF ENERGY SAVINGS BY IRRIGATION ACCORDING TO PLANT NEEDS	$194.50 to $209 in net energy savings	per year per 40-acre field

Ponding at the lower end of the field and water flowing along the roads is evidence of overwatering. Irrigate according to plant needs rather than following a set number of days on the calendar. You can improve irrigation efficiency by using aids such as soil augers, evaporation pans, and moisture meters. They help to accurately determine when and how much to apply. They are much better than trying to eyeball it. The results are reduced total water used in a season, reduced energy used for pumping, and increased money in your pocket.

Suppose that overwatering results in a 10-percent waste of water per year. Assume also a medium-power requirement of 60 pounds per square inch and a 200-foot lift on a side roll system covering 40 acres with 30 acre inches applied per year. The extra water pumped requires 12.75 gallons of diesel fuel or 152.5 kilowatt hours per acre. On a 40-acre field this could mean $230 or more a year in saved energy.

Nonenergy Costs: Cost of monitoring equipment ranges from $20 to $50. If it lasts more than one year, the net savings will be greater than shown in this example.

Calculations

Diesel-powered pump

0.25 acre foot x 51 gal of diesel per acre foot = 12.75 gal of diesel

12.75 gal of diesel x 40 acres x $.45 per gal of diesel = $229.50

Net savings: $229.50 diesel saving - $35 cost of monitoring equipment = $194.50

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$204.00	$229.50	$255.00	$280.50

Electric-powered pump

0.25 acre foot x 610 kWh per acre foot = 152.5 kWh

152.5 kWh x 40 acres x $.04 per kWh = $244

Net savings: $244 electric savings - $35 costs of monitoring equipment = $209

Dollars Saved at Various Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$183	$244	$305	$366

Most livestock producers know how much their electricity and fuel bills have gone up during the last years, but few know how many kilowatt hours of electricity or gallons of diesel, gasoline, or LP gas they use or what they use it for. In evaluating the amount of energy used on the farm, look at the amount needed to perform different tasks. The recordkeeping charts in this section will help producers determine where and in what amounts they use energy.

Recording Energy Use

The following six recordkeeping tables will help a producer to keep track of total energy use by type and assign the right portion of it to livestock production. Energy Recordkeeper Number 1 is for electricity. If power for the livestock facilities goes through a separate meter, then the producer makes one entry in the livestock column of Energy Recordkeeper Number 1. If the electric power all goes through only one meter, the producer will have to estimate average kilowatts used following the suggestions in the footnotes to Energy Recordkeeper Number 1.

Energy Recordkeeper Number 2 is for LP or natural gas. If a producer uses LP and natural gas, he will have to use a separate sheet for each.

Energy Recordkeepers Number 3 and Number 4 are for tractor fuel. Energy Recordkeeper Number 3 is for the total tractor use and includes a column for hourly fuel use. Hourly fuel use can be an early warning that the tractor or equipment needs some attention. It also indicates the energy demands of different operations. Energy Recordkeeper Number 4 is for tractor time and fuel used in livestock production and uses information from Recordkeeper Number 3.

Energy Recordkeepers Number 5 and Number 6 are for truck and automobile fuel. These are set up to utilize odometer readings and to figure miles per gallon. Allocation of truck and auto use may be even more difficult than allocation of tractor hours. Approximate in instances where a detailed log of use is not maintained.

Energy Recordkeeper Number 1

(electricity use record 197_)

Month and year	Total kilowatts 1/	Kilowatts for home use 2/	Kilowatts for livestock 3/	Kilowatts for other farm work 3/
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Year				

1/ Record from monthly utility bill. Only column 3 will be necessary if livestock are served through a separate meter.

2/ Record an allowance for home use, typically 500 to 600 kilowatt hours per month excluding air conditioning and electric heat. See table 8 on page 53 for guides on selected home equipment.

3/ Estimate kWh of electricity either for livestock or other farm purposes, whichever is the easiest, and assign the remainder to the use not estimated. For example, much electric power is often used in grain drying where both motor size and hours of operation are known. After deducting electricity for home use, the remainder minus that for grain drying, a little for the shop, and a yard light would be chargeable to livestock.

Energy Recordkeeper Number 2

(LP or natural gas use record 197_)

Month and year	Total gallons (or ft^3) 1/	Gallons for livestock (or ft^3) 2/	Gallons for other farm work (or ft^3) 2/
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
Year			

1/ Read tank gauge or meter. Deduct amount for home use if both farm and home use the same supply.

2/ Estimate the use for whichever is clearest and leave the remainder for the other. For example, other farm work may be grain drying for which both hours of use and gas consumption per hour are easily figured. Charge the remainder to livestock.

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Energy Recordkeeper Number 3

(tractor fuel use record 197_)

Date Filled	Tractor No. 1 ( ) 1/				Tractor No. 2 ( ) 1/			
	Hour meter reading 2/	Hours use	Fuel		Hour meter reading 2/	Hours use	Fuel	
			Total	Per hour			Total	Per hour
		Hours	Gallons			Hours	Gallons	
January 3	1,680							
January 6	1,690	10	35	3.5				
January 10								
-								
-								
-								
-								
Year								

1/ Record fuel used--diesel, gasoline or LP gas.

2/ At first filling, record hour meter reading and gallons of fuel added to completely fill the tank. At next filling, record new hour meter reading, figure operating time and fuel use per hour. Continue as running record and compute totals and averages for the year.

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Energy Recordkeeper Number 4

(tractor time and fuel chargeable to livestock 197_)

Month and year	Tractor No. 1 ( ) 1/			Tractor No. 2 ( ) 1/		
	Hours for livestock 2/	Fuel use 3/		Hours for livestock 2/	Fuel use 3/	
		Per hour	Total		Per hour	Total
	Hours	Gallons		Hours	Gallons	
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Year						

1/ Record fuel used--diesel, gasoline or LP gas.

2/ List only the tractors used in livestock production or forage harvesting. Total hours of use for each tractor is known from Recordkeeper Number 3. Make your estimate here of the hours spent each month on livestock work and forage harvesting. Dates of fueling and operating times from Recordkeeper Number 3 should help.

3/ Fuel use per hour depends on the load on the tractor. Consult hourly use rates by dates in Recordkeeper Number 3 to help set accurate fuel use rates per hour.

Energy Recordkeeper Number 5

(truck and auto fuel use record 197_)

Date filled	Truck No. 1 ( ) 1/				Truck No. 2 ( ) 1/			
			Fuel				Fuel	
	Odometer reading 2/	Miles	Total gal	Miles per gal	Odometer reading 2/	Miles	Total gal	Miles per gal
January 3	8,200							
January 6	8,360	160	20	8				
January 10								
-								
-								
-								
Year								

1/ Record fuel used--gasoline, diesel, or LP gas.

2/ At first filling, record odometer reading and gallons of fuel added to completely fill the tank. At next filling, record new odometer reading, figure miles travelled, and miles per gallon of fuel. Continue a running record and compute totals and averages for the year.

Energy Recordkeeper Number 6

(truck and auto miles and fuel chargeable to livestock 197_)

Month and year	Truck No. 1 ( ) 1/			Truck No. 2 ( ) 1/			Auto		
	Miles for livestock 2/	Miles per gallon 3/	Total gallons	Miles for livestock 2/	Miles per gallon 3/	Total gallons	Miles for livestock 2/	Miles per gallon 3/	Total gallons
Jan.									
Feb.									
Mar.									
Apr.									
May									
June									
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									
Year									

1/ Record fuel used--diesel, gasoline or LP gas.

2/ Total miles driven for each vehicle is known from Energy Recordkeeper No. 5. Make your estimate here of the miles driven each month on livestock work and forage harvesting. Dates of fueling and miles driven from Energy Recordkeeper No. 5 should help.

3/ Miles per gallon depend on both speed and load. Consult miles per gallon of fuel by dates in Energy Recordkeeper No. 5 to help set accurate miles per gallon.

Table 8

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.

Annual energy requirement of electric household appliances

	Est. kWh consumed annually 1/
FOOD PREPARATION	
Blender	15
Broiler	100
Carving knife	8
Coffee maker	106
Deep fryer	83
Dishwasher	363
Egg cooker	14
Frying pan	186
Hot plate	90
Mixer	13
Oven, microwave (only)	190
Range	
with oven	1,175
with self-cleaning oven	1,205
Roaster	205
Sandwich grill	33
Toaster	39
Trash compactor	50
Waffle iron	22
Waste disposer	30
FOOD PRESERVATION	
Freezer (15 ft^3)	1,195
Freezer (frostless 15 ft^3)	1,761
Refrigerator (12 ft^3)	728
Refrigerator (frostless 12 ft^3)	1,217
Refrigerator/freezer (14 ft^3)	1,137
(Frostless 14 ft^3)	1,829
LAUNDRY	
Clothes dryer	993
Iron (hand)	144
Washing machine (automatic)	103
Washing machine (nonautomatic)	76
Water heater	4,811

	Est. kWh consumed annually 1/
COMFORT CONDITIONING	
Air cleaner	216
Air conditioner (room)	860 2/
Bed covering	147
Dehumidifier	377
Fan (attic)	291
Fan (circulating)	43
Fan (rollaway)	138
Fan (window)	170
Heater (portable)	176
Heating pad	10
Humidifier	163
HOME ENTERTAINMENT	
Radio	86
Radio/record player	109
Television	
black & white	
tube type	350
solid state	120
color	
tube type	660
solid state	440
HOUSEWARES	
Clock	17
Floor polisher	15
Sewing machine	11
Vacuum cleaner	46

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

2/ Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit.

Source: Electric Energy Association, 90 Park Ave., New York, New York

Every farmer or rancher should start keeping records by making a job-by-job buildup of the energy requirements of the things that he does in livestock production.

ELECTRICITY AND GAS

Tables 4* 8* and 9* and figure 4* can be used as a first approximation of energy use by various production systems. However, get an engineer to assist in planning a total system.

Grain drying should be considered in any evaluation of energy use in livestock production because: (1) the processing and storage of grain is an inseparable part of the livestock production system; (2) grain drying requires lots of energy, especially LP or natural gas, often twice as much as that spent on all other grain producing activities combined; and (3) alternatives are available for storing, preserving, and feeding grain without drying it. Grain drying, however, has not been included in the energy use tables because it is affected by too many variables. Producers are advised to get special reports from their State Extension Services on options available for drying grain and for handling high moisture grain.

Small electric motors are less efficient than large motors. Horsepower and kilowatt hours are equated on a 1-to-1 basis only for large motors. For example, a 1-horsepower electric motor uses an average of 1.84 kilowatts per hour of operation; a 10-horsepower motor uses 11.50 kilowatts per hour. With three-phase service the 1-to-1 ratio more closely approximates actual use of electricity, but even here the smaller motor is less efficient than the larger ones.

*Table 4, page 14 Figure 4, page 26
Table 8, page 53
Table 9, page 56

TRACTOR FUEL

The rate at which tractors use fuel while doing different work is not well documented or understood. Most planning guides provide just one rate. However, Nebraska tests on tractors provide data to make much more accurate estimates of fuel use: Figures 5* (diesel) and 6* (gasoline) have been developed from the Nebraska test data to help in estimating tractor fuel use per hour. The data reflect averages for tractors tested since 1969, assume that engines are properly tuned, and exclude four-wheel drive units.

Figure 5 shows fuel use per hour for five diesel tractors ranging from 50 to 150 horsepower. Two fuel estimating lines are given for each size tractor; one for full engine speed and one for half engine speed. Near full engine speed is needed for most power takeoff operations.

Take the 100-horsepower diesel tractor in figure 5 as an example. Place a straight edge across the page. At full engine speed developing the maximum of 100 horsepower, fuel use is about 6.7 gallons per hour. Move the straight edge down the page until the 100-horsepower tractor is developing only 50 horsepower at full engine speed. Read along the left side of the page to find that fuel use has dropped to 4.4 gallons per hour. Similarly, full engine speed for the 100-horsepower diesel tractor will use 2.2 gallons of fuel per hour when there is no load on the tractor. Do the same for the 100-horsepower gasoline tractor in figure 6; fuel used per hour is considerably higher at each level. Commonly, diesel tractors use only about 70 percent as much fuel per hour as gasoline tractors of the same size doing the same work.

*Figure 5, page 70
Figure 6, page 71

For tractors other than the sizes given in figures 5 and 6, simply draw in fuel estimating lines for these sizes. For example, to estimate fuel use per hour for a 60-horsepower tractor, read up from 60 horsepower along the bottom of the right figure until the diagonal line that passes through zero in the lower left corner of the figure is intersected. Then with a straight edge draw a fuel estimating line for a 60-horsepower tractor parallel to the others in the figure.

Many jobs do not require full (standard for power takeoff) engine speed of the tractor. Reducing engine speed saves fuel. The effect on fuel use per hour of half speed is shown in figures 5 and 6. The vertical arrows indicate the drop in fuel use per hour, the maximum horsepower that can be developed at half speed, and the beginning of the fuel estimating line for half speed.

To draw fuel estimating lines for half speed for tractors other than the sizes given, take 58 percent of the rated horsepower for diesel tractors or 61 percent for gasoline tractors. Start the half speed fuel estimating line from the diagonal at that point. For example, 58 percent of the 60-horsepower diesel used in the previous example is 35 horsepower. Read up from 35 horsepower to the diagonal line passing through zero. Then set the half speed fuel estimating line for the 60-horsepower tractor parallel to the other estimator lines in the figure.

TRACTOR POWER REQUIREMENTS

Research has measured the power requirements of farm operations and forms the basis for the guidelines in this section. Jobs, working conditions, and equipment also affect power requirements. In using the guidelines, use judgment based on experience.

Many tractor-powered jobs in livestock production require power for three purposes: (1) to operate the machine, usually pto power; (2) to move the weight of the equipment; and (3) to move the weight of the tractor. Build up the power requirements for the job by estimating each demand on the tractor engine.

Table 10* gives power requirement guides. If the equipment used is not listed in table 10, pick an item with similar operating characteristics. Do not confuse power guidelines listed in table 10 with performance of the typical suburban lawn and garden tractors of 10 to 15 horsepower. They are not the same as farm-size tractors.

Power to move an implement depends on weight, speed, and condition of the travel surface. Estimates in table 11 are based on these three factors.

Implement and load weights should be rounded upward to the nearest whole ton. Table 10 is a guide for either weight or typical operating speed in miles per hour.

Farming hilly country may require larger tractors just to have enough reserve power to get up slopes. For example, pulling a load up a 10-percent slope takes about 3 times as much horsepower as moving the same load at the same speed on level ground.

Table 12* gives the horsepower needed to move tractors of 35 to 150 horsepower over different travel surfaces at 1 mile per hour. Interpolate for tractor sizes in between those given in table 12. To determine specific job power requirements, identify the size of the tractor and conditions of the travel surface, then multiply the value in table 12 by the speed.

*Table 10, pages 60-65
Table 12, page 67

Table 9--Guides to use of electricity and gas in livestock production

Function	Facility: Type	Facility: Size	Power unit 1/: Type	Power unit 1/: Size	Energy per unit: Electricity (kWh)	Energy per unit: LP gas 2/ (gal)	Comment
Light	Farrowing house	20 crate	Bulbs	800 watts	720/y	---	Incandescent lamps. House used year round.
Light	Nursery	1,000 ft^2	Bulbs	600 watts	430/y	---	Incandescent lamps. House used year round.
Light	Open hog shed	3,000 ft^2	Bulbs	600 watts	220/y	---	Incandescent lamps. House used year round.
Light	Closed hog barn	3,000 ft^2	Bulbs	1,600 watts	1,150/y	---	Incandescent lamps. House used year round.
Light	Feed house	1,000 ft^2	Bulbs	100 watts	360/y	---	Incandescent lamps. House used year round.
Light	Open cattle shed	3,000 ft^2	Bulbs	600 watts	430/y	---	Incandescent lamps. House used year round.
Light	Pole light	---	Lamp	400 watts	1,890/y	---	Mercury vapor. Used year round.
Fence	Electric	One unit	Charger	10 watts	84/y	---	Handles 160 rods of fence.
No freeze	Water tank	80 gal	Heat element	1,000 watts	1,750/y	---	For moderate zone. Use 125 percent for cold zone; 50 percent for mild zone (see fig. 4).*
No freeze	Waterer	2 drinker	Heat element	800 watts	1,450/y	---	For moderate zone. Use 125 percent for cold zone; 50 percent for mild zone (see fig. 4).*
Pump water	Well	4 inch	Motor	1 hp	1.23/1,000 gal	---	Lift 60 feet. Greater lifts require more power.
Grind & mix	Mixer mill	3 hp	Motor	3 hp	7.82/ton	---	Medium grind of 0.5 ton per hour.
Pre-mix	Pre-mixer	250 lb	Motor	0.5 hp	1.13/ton	---	Mix 1.0 ton per hour.
Unload grain	Boot auger	4 in x 10 ft	Motor	0.5 hp	0.16/ton	---	Unload 7.0 tons per hour.
Unload ground feed	Boot auger	4 in x 10 ft	Motor	0.5 hp	0.23/ton	---	Unload 5.0 tons per hour.
Convey grain	Auger	4 in x 10 ft	Motor	0.5 hp	0.16/ton	---	Convey 7.0 tons per hour for 10 feet. Add 0.25 hp for each additional 10 feet.

See footnotes at end of table.

*Figure 4 is on page 26.

Table 9--Guides to use of electricity and gas in livestock production--Continued

Function	Facility		Power unit 1/		Energy per unit		Comment
	Type	Size	Type	Size	Electricity (kWh)	LP gas 2/ (gal)	
Convey ground feed	Auger	4 in x 10 ft	Motor	0.5 hp	0.23/ton	---	Convey 5.0 tons per hour for 10 feet. Add 0.25 hp for each additional 10 feet.
Blow feed	Pneumatic	1-inch tube	Motor	3.0 hp	13/ton	---	Requires 1 hp hour per ton per 100 feet.
Ventilate	Farrowing house	20 crate	Motor	0.25-2 hp	8,640/y	---	For moderate zone. Use 110 percent for mild zone; 90 percent for cold zone.
Ventilate	Nursery	1,000 ft^2	Motor	0.25-2 hp	8,640/y	---	For moderate zone. Use 110 percent for mild zone; 90 percent for cold zone.
Ventilate	Closed hog barn	3,000 ft^2	Motor	0.25-4 hp	17,290/y	---	For moderate zone. Use 110 percent for mild zone; 90 percent for cold zone.
Heat	A-frame	1 sow	Lamp	250 watts	40/litter	---	Used during 8 months cold zone; 6 months moderate zone; 4 months mild zone.
Heat	Farrowing house solid floor	20 crate	Lamp Gas heater Fan motor	150 watts 40,000 Btu 0.25-1 hp	1,000/y --- 1,440/y	--- 800/y ---	House used year round. For moderate zone. Use 150 percent of lamp and gas; 133 percent of fan for cold zone. Use 50 percent of lamp and gas; 67 percent of fan for mild zone.
Heat	Farrowing house slotted floor	20 crate	Gas heater Fan motor	40,000 Btu 0.25-1 hp	--- 1,440/y	590/y ---	Same except no heat lamp.
Heat	Farrowing [illegible] slotted f[illegible]	20 crate	Gas furnace Water pump motor	24,000 Btu 0.25-1 hp	--- 1,440/y	470/y ---	Same except no heat lamp. Water pump operates same time as fan above.
Ventilate	Closed cattle barn	4,500 ft^2	Motor	2-1.0 hp	24,200/y	---	For 200 head of beef cattle in closed, warm confinement barn, moderate zone. Use 110 percent for mild zone; 90 percent for cold zone.

Table 9--Guides to use of electricity and gas in livestock production--Continued

Function	Facility		Power unit 1/		Energy per unit		Comment
	Type	Size	Type	Size	Electricity (kWh)	LP gas 2/ (gal)	
Heat	Nursery solid floor	1,000 ft^2	Gas heater Fan motor	40,000 Btu 0.25-1 hp	--- 720/y	880/y ---	House used year round. For moderate zone. Use 180 percent of gas and 133 percent of fan for cold zone; 45 percent of gas and 67 percent of fan for mild zone.
Heat	Nursery slotted floor	1,000 ft^2	Gas heater Fan motor	40,000 Btu 0.25-1 hp	--- 720/y	780/y ---	House used year round. For moderate zone. Use 180 percent of gas and 133 percent of fan for cold zone; 45 percent of gas and 67 percent of fan for mild zone.
Unload grain	Sweep auger	20-ft diameter	Motor	3 hp	3.26/1,000 bu	---	Unload 1,200 bu dry grain per hour.
Aerate lagoon	Manure lagoon	1 acre	Motor	2 hp	1,960/mo		Requires continuous operation for 9 months in cold zone, 10 months in moderate zone, 12 months in mild zone.
Oxidize manure	Oxidation wheel	1 unit	Motor	5 hp	56,410/y	---	Operates continuously and handles up to 140 feet of raceway.
Pressure spray	Booster pump	500 psi	Motor	0.75 hp	1.59/h	---	Use 4 hours to clean 20 crate farrowing house.
Clean	Steam cleaner	High pressure	Gas heater	40,000 Btu	---	0.43/hr	Use 6 hours to clean 20 crate farrowing house.
Unload high moisture shelled corn	Bottom silo unloader	3 hp	Motor	3 hp	0.65/ton	---	Unload 6 tons per hour.
Unload corn silage	Bottom silo unloader	7.5 hp	Motor	7.5 hp	1.42/ton	---	Unload 6.5 tons per hour. Handles grass-legume silage at 3.25 tons per hour.
Unload corn silage	Tower surface unloader	150-ton silo	Motor	5.0 hp	1.43/ton	---	Unload 4.5 tons per hour. Handles grass-legume silage at 2.25 tons per hour.

Table 9--Guides to use of electricity and gas in livestock production--Continued

Function	Facility		Power unit 1/		Energy per unit		Comment
	Type	Size	Type	Size	Electricity (kWh)	LP gas 2/ (gal)	
Unload corn silage	Tower surface unloader	470-ton silo	Motor	5.0 hp	0.99/ton	---	Unload 6.5 tons per hour. Handles grass-legume silage at 3.25 tons per hour.
Unload corn silage	Tower surface unloader	1,080-ton silo	Motor	7.5 hp	1.42/ton	---	Unload 6.5 tons per hour. Handles grass-legume silage at 3.25 tons per hour.
Elevate feeds	Flight elevator	10" x 20'	Motor	1.0 hp	1.84/h	---	Add 1.0 hp for each additional 20 feet of elevator.
Feed by auger	Auger feeder	9" x 125'	Motor	5.0 hp	6.44/h	---	For maximum of 125 feet of auger.
Feed by belt	Belt feeder	125'	Motor	5.0 hp	6.44/h	---	For maximum of 125 feet of belt.
Roll high moisture shelled corn	Roller mill	10"	Motor	5.0 hp	1.07/ton	---	Moisture content 25 percent.
Grind corn	Hammer mill	10"	Motor	10.0 hp	5.75/ton	---	Dry shelled corn.

1/ Use of electricity by electric motors is determined at the rates shown for single-phase motors in table 4.

2/ One gallon of LP gas is the equivalent of 92 ft^3 of natural gas.

3/ Total wattage of bulbs.

Table 10--Estimated tractor horsepower to operate selected implements used in livestock production, typical travel speeds for mobile operations and weight of implement 1/

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Mow, sickle bar, stem plants	5	0.3-0.4	0.4-0.6 hp per foot of width	Use highest value for heavy growth.
Mow, sickle bar, grasses	5	0.3-0.4	0.5-1.0 hp per foot of width	Use highest value for heavy growth or mature grasses.
Mow, rotary	5	0.5	3-8 hp per foot of width	Use highest value for heavy or tough forages.
Crimp or condition hay	5	1.2-1.5	1.5-2.5 hp per foot of width	Use highest value for large volume.
Windrower with conditioner self-propelled	5	2.0-4.0	2.0-3.5 hp per foot of width	Use highest value for large volume.
Rake hay, side delivery	4	0.3-0.5	0.2-0.3 hp per foot of width	Add 50 percent for high moisture (40-70 percent) crops.
Bale hay, 40-60 lb bales	4	1.2-1.8	1.5-2.5 hp per ton per hour	Use higher values for larger hay inputs. Add weight of half-loaded, trailing wagon, if any.
Bale hay, 0.75-ton round bale	4	1.7-2.0	1.8-2.6 hp per ton per hour	Add one-half weight of bale to implement weight.

See footnotes at end of table.

Table 10--Estimated tractor horsepower to operate selected implements used in livestock production, typical travel speeds for mobile operations and weight of implement 1/--Continued

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Bale hay, 1.5-ton round bale	4	2.0-2.5	1.8-2.6 hp per ton per hour	Add one-half weight of bale to implement weight.
Stacking wagon, 1.5-ton stack	4	2.5	1.1-2.5 hp per ton per hour	Add 0.75-ton load to implement weight.
Stacking wagon, 3.0-ton stack	4	4.0	1.1-2.5 hp per ton per hour	Add 1.5-ton load to implement weight.
Stacking wagon, 5.0-ton stack	4	6.0	1.1-2.5 hp per ton per hour	Add 2.5-ton load to implement weight.
Chop grass-legume forage, wet 6-foot cutter bar	3	1.4-2.0	1.0-4.0 hp per ton per hour	Finer cut, higher yields, drier forage, more grasses--all increase power.
Chop grass-legume forage, wilted 6-foot cutter bar	3	1.4-2.0	1.0-8.0 hp per ton per hour	Finer cut, higher yields, drier forage, more grasses--all increase power.
Chop grass-legume forage, windrowed hay, trail load	3	1.2-1.7	2.0-5.0 hp per ton per hour	Finer cut, higher yields, drier forage, more grass--all increase power. Add weight of half-loaded wagon to implement weight.

Table 10--Estimated tractor horsepower to operate selected implements used in livestock-production, typical travel speeds for mobile operations and weight of implement 1/--Continued

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Chop corn silage, 1 row, trail load	3	1.1-1.7	1.0-2.5 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.
Chop corn silage, 2 row, trail load	3	1.2-1.8	1.0-2.5 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.
Chop stalkage 12-ft. cutter cutter bar, self-propelled, 3 row	3	6.5-7.0	1.0-2.5 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.
Chop haylage 12-ft. cutter cutter bar, self-propelled, 3 row	3	6.5-7.0	2.5-5.0 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.
Chop hay, 12-ft cutter self-propelled, 3 row	3	6.5-7.0	2.0-5.0 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.
Chop earlage, 2 row, trail load	3	1.2-1.8	1.0-2.5 hp per ton per hour	Finer cut and higher yields increase power. Add weight of half-loaded wagon to implement weight.

Table 10--Estimated tractor horsepower to operate selected implements used in livestock production typical travel speeds for mobile operations and weight of implement 1/--Continued

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Grind dry shelled corn, hammer mill	0	0	9.0 hp per ton per hour	Horsepower increases with fineness of grind. Reduce to 4.5 hp with 1/4 inch screen.
Grind 25 percent moisture shelled corn, hammer mill	0	0	11-14 hp per ton per hour	Horsepower increases with fineness of grind.
Grind dry ear corn, hammer mill	0	0	7.5-10 hp per ton per hour	Horsepower increases with fineness of grind.
Grind baled hay, tub grinder	0	0	10-20 hp per ton per hour	Horsepower increases with fineness of grind.
Grinder-mixer, corn and supplement, mobile, 1.0-ton capacity	2	1.5-2.0	11-17 hp per ton per hour	Horsepower increases with fineness of grind. Add tons of capacity to implement weight.
Load corn silage, front-end loader, bunker silo, 0.5 ton	2	0.5	0.2 hp per ton per hour	
Feed grain with self-unloading wagon	2	0.5-0.8	0.1 hp per ton per hour	Add weight of load to implement weight.
Feed silage with self-unloading wagon	2	1.5-1.8	0.1 hp per ton per hour	Add weight of load to implement weight.

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Table 10--Estimated tractor horsepower to operate selected implements used in livestock production, typical travel speeds for mobile operations and weight of implement 1/--Continued

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Scrape paved feedlot	2	0.2-0.4	1.0-2.0 hp per foot of width	
Load manure, front-end loader	2	0.4-0.7	0.2 hp per ton per hour	Add 0.5 to 1.0 tons to implement weight for full bucket loads.
Pump liquid manure from pit	0	0	1.0 hp per 100 gal/min	
Pump liquid manure from pit using chopper pump	0	0	2.0 hp per 100 gal/min	
Spread solid manure, 3-ton	6	0.8-1.2	2.0-5.0 hp	Add weight of load to implement weight.
Surface spread liquid manure, 750-gallon tank	6	1.0	10 hp	Add weight of load to implement weight.
Surface spread liquid manure, 1,500-gallon tank	6	1.5-2.0	10 hp	Add weight of load to implement weight.
Surface spread liquid manure, 2,250-gallon tank	6	2.5	10 hp	Add weight of load to implement weight.

Table 10--Estimated tractor horsepower to operate selected implements used in livestock production, typical travel speeds for mobile operations and weight of implement 1/--Continued

Operation	Typical speed	Implement weight 2/	Pto power for operation 3/	Comment
	Miles/h	Tons	Horsepower	
Soil inject liquid manure, 2,250 gallon tank	4	3.0	30 hp	Add weight of lo[illegible] implement weight. [illegible] two injectors workin[illegible] inches deep.
Irrigate from runoff holding pond	0	0	10 hp per 100 gal/min	Add 0.1 hp for each 100 feet of 4-inch pipe.
Pull loads	Variable	Variable	Rolling power only	See tables 11 and 12 for hp values.
Drive tractor only	Variable	Variable	Rolling power only	See table 12 for hp values.
Fill tower silo	0	0	0.5-2.0 hp per ton per hour	Least for high moisture grain; most for wilted forage.

1/ All implements are assumed to be in good operating condition.

2/ Weight of the implement. Applies only to mobile operations. Does not include the weight of either tractor or trailing wagon.

3/ Does not include the horsepower needed to move either the implement or the tractor. See tables 12 and 13 for estimates of these values.

Table 11--Approximate horsepower required to move loads one mile per hour over various surfaces 1/

Load (tons)	Kind of surface		
	Good	Fair	Poor
1	0.3	0.8	1.3
2	0.5	1.6	2.7
3	0.8	2.4	4.0
4	1.1	3.2	5.3
5	1.3	4.0	6.7
6	1.6	4.8	8.0
7	1.8	5.6	9.4
8	2.1	6.4	10.7
10	2.7	8.0	13.3
12	3.2	9.6	16.0
15	4.0	12.0	20.0
20	5.3	16.0	26.7

1/ Coefficients of rolling resistance are 0.05, 0.15, and 0.25 for the three progressively rougher surfaces. Estimates assume that surfaces are relatively level. Load includes weight of implement and anything on it. For higher speeds, multiply the table values by the miles per hour desired. A "good" surface is hard, smooth ground, a hard farm road, or the equivalent. A "fair" surface is a sloppy paved feedlot, cultivated land, rough but hard ground, or the equivalent. A "poor" surface is plowed ground, muddy ground, or the equivalent.

Table 12--Approximate horsepower required to move tractors one mile per hour over different kinds of surfaces 1/

Tractor (horsepower)	Kind of surface		
	Good	Fair	Poor
35	0.7	2.0	3.4
50	0.9	2.8	4.6
75	1.3	4.0	6.6
100	1.6	5.0	8.2
125	1.9	5.7	9.6
150	2.2	6.5	10.9

1/ Coefficients of rolling resistance are 0.05, 0.15 and 0.25 for the three progressively rougher surfaces. Estimates assume that surfaces are relatively level and the tractor has average wheel weights and fuel load. For higher speeds, multiply table values by the miles per hour desired. A "good" surface is hard, smooth ground, a hard farm road, or the equivalent. A "fair" surface is a sloppy paved feedlot, cultivated land, rough but hard ground, or the equivalent. A "poor" surface is plowed ground, muddy ground, or the equivalent. Shipping weight of small tractors is about 100 pounds per power takeoff horsepower; 75 pounds per power takeoff horsepower for large tractors. Weight is greater with wheel weights and fuel loads.

EXAMPLE OF SAVINGS BY USE OF TRACTOR FUEL IN CATTLE FEEDING

A farm produces a substantial acreage of crops and feeds out [illegible] steer calves each year in dry lot on a [illegible] concentrate ration with some hay. Its tractors include a 125-horsepower diesel, two 75-horsepower diesels, one 50-horsepower diesel, and one 50-horsepower gasoline tractor. The number and sizes of these tractors are determined by the peak seasonal work load on a particular farm.

The producer may never have thought much about the tractor fuel used in livestock work. Until recently fuel was rather inexpensive, and the major part of it went into crop production anyway. It was simple to use the field crop tractors for everything. Often a separate tractor was hooked to each implement to avoid the trouble of hookups.

Now, fuel not only costs much more, but may be in short supply periodically.

So let's look at ways a producer can cut the amount of tractor fuel used in feeding operations.

First, the producer should estimate his current use of tractor fuel in livestock work. He can try then to reduce fuel use by rematching tractors and implements. Finally, he should look for ways to cut fuel use even further by improving the way operations are done, and eliminating some tasks.

Table 13* is the worksheet for estimating how much fuel currently is being used by the cattle feeder. Here is how it should be completed column by column.

*Table 13, page 75.

*Table 10, page 60.

Column 1. A list including [illegible] major operation. The farmer [illegible] include hay harvest so he starts with mowing, then lists crimping, raking, and so on through use of a tractor for miscellaneous work and travel.

Column 2. The horsepower of the tractor that is used for each operation listed in column 1.

Column 3. The fuel (diesel, gasoline, LP) used by the tractors listed in column 2.

Column 4. The usual speed the engine is run for each of the operations. He records "standard" speed for most of the pto operations. This is close to full engine speed for most tractors. Some are estimated at half or full engine speeds, but other speeds, such as three-quarters, can be recorded if appropriate.

Column 5. The condition of the travel surface for those operations that are not stationary. He uses "good" for roads, hard ground, or the equivalent; "fair" for cultivated land, a sloppy feedlot, rough pastures, or the equivalent; "poor" for plowed ground, heavy manure in a feedlot, muddy ground, or the equivalent.

Column 6. Travel speed in miles per hour for mobile operations. He checks the typical speeds given in table 10* to make sure that the travel speeds he records seem reasonable.

Column 7. Weight of the implement and its load to the nearest ton above actual weight. He knows what most of his implements weigh, plus the loads they carry, but he needs to check items which he does in table 10.

Column 8. The horsepower needed to operate the implement. He uses data from table 10, modified by his own experience to estimate power requirements. Some seem exceptionally low, and he must continually remind himself that more power will be added to move the implement and the tractor. Besides, use of large field tractors has gotten him accustomed to greatly overpowering many jobs in his cattle feeding operation.

Column 9. The horsepower needed to move the implement for mobile operations. He uses data in table 11, along with the weight, travel speed, and condition of travel surface that he has recorded in columns 5, 6, and 7 of this table. Table 11 is on page 66.

Column 10. The horsepower needed to move the tractor for mobile operations. He uses table 12 for his basic information, again noting the speed and travel surface that he recorded in columns 5 and 6 of this table on page 67.

Column 11. Total horsepower needed for operation. He adds the values in columns 8, 9, and 10.

Column 12. Estimated tractor hours per year for each operation. Estimating average hours per day, plus days worked for each operation, results in a fairly accurate figure for each operation. Knowing the beginning and end-of-year hourmeter readings on each tractor helps, especially with assigning a value to miscellaneous travel.

Column 13. Fuel use per hour. For diesel tractors he goes to figure 5, picks out the fuel estimator line for the size tractor that he uses, notes the horsepower that the operation takes, and reads the gallons of fuel used per hour on the left of the page. He does the same for each successive operation, sometimes using the full speed estimator line; sometimes the half speed line as indicated by his engine speed recordings in column 4 of this table. He considers "standard" the same as full speed for estimating fuel use per hour. The same procedure is followed with figure 6 whenever the gasoline tractor is used. Had his tractor sizes been other than those presented in figures 5 and 6, he would first have had to draw in fuel estimator lines to represent them as described earlier.

Columns 14 and 15. Total fuel use per year for each operation. He multiplies fuel use per hour (column 13) by operating hours per year (column 12) and puts the answers in column 14 if diesel was used; column 15 if the fuel was gasoline.

This detailed examination of this cattle feeding enterprise shows that it consumes 1,667 gallons of diesel and 472 gallons of gasoline in a year. This farmer thinks he already sees several good possibilities for saving fuel, but first he wants to see what can be accomplished simply by rematching tractors to implements. The need for doing several things simultaneously may not allow him to use the most economical tractor in every instance, but he will make adjustments for that in a final step. He estimates and records the fuel that could be saved simply by changing tractors in table 14. Let's follow through as he rematches tractors and implements. [illegible] on page 76.

Saving Fuel By Better Matching of Tractors and Implements

Column 1. A list of the operations is the same as in column 1 of table 13.

Column 2. The horsepower needed to both operate and move the implement. Adding the values in columns 8 and 9, table 13 gives this answer.

Column 3. Travel speed is the same as column 6, table 13.

Column 4. Engine speed required. To answer this correctly, the farmer must know the operating specifications of his equipment. For items of which he

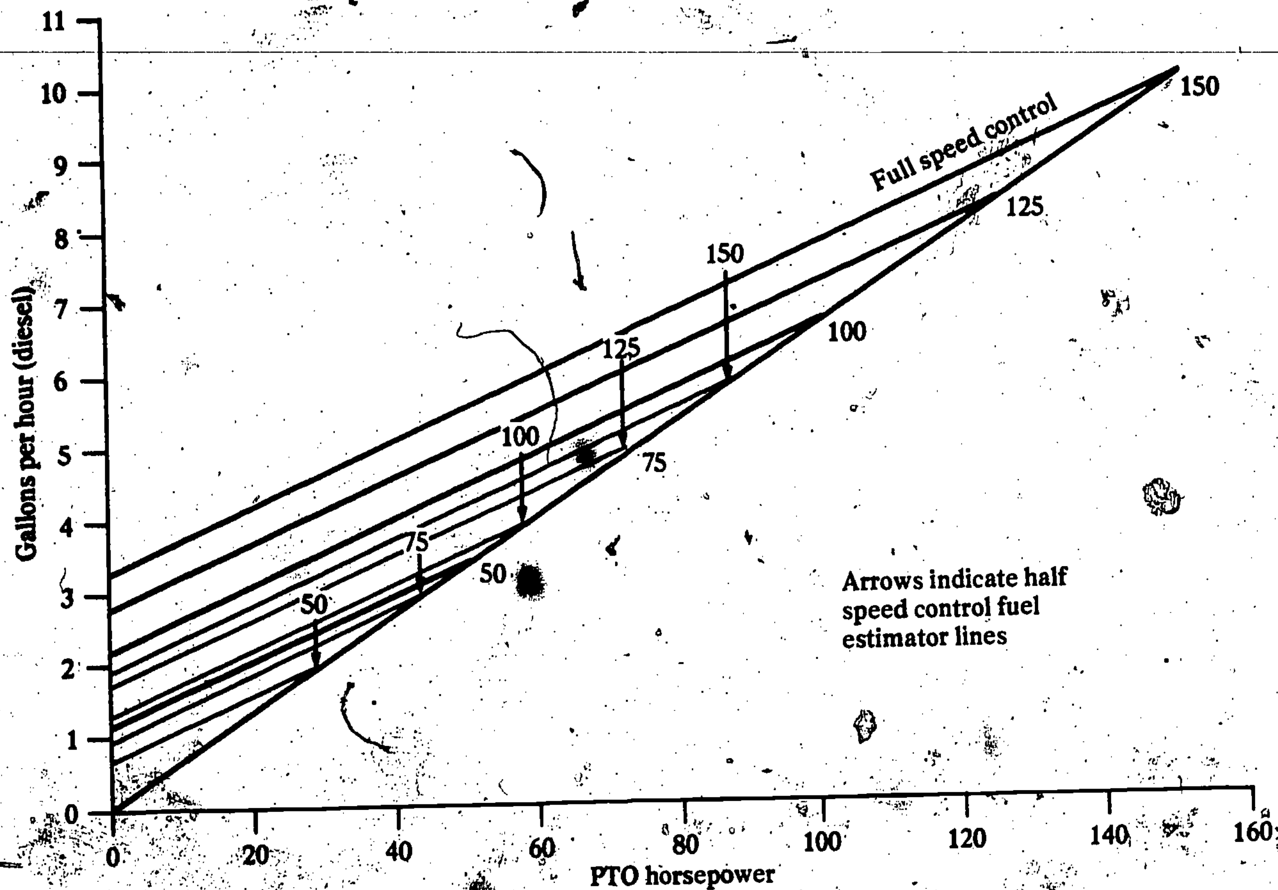

Figure 5 : USE OF FUEL PER HOUR BY DIESEL TRACTORS AT FULL AND HALF ENGINE SPEEDS AND VARYING POWER DEMANDS

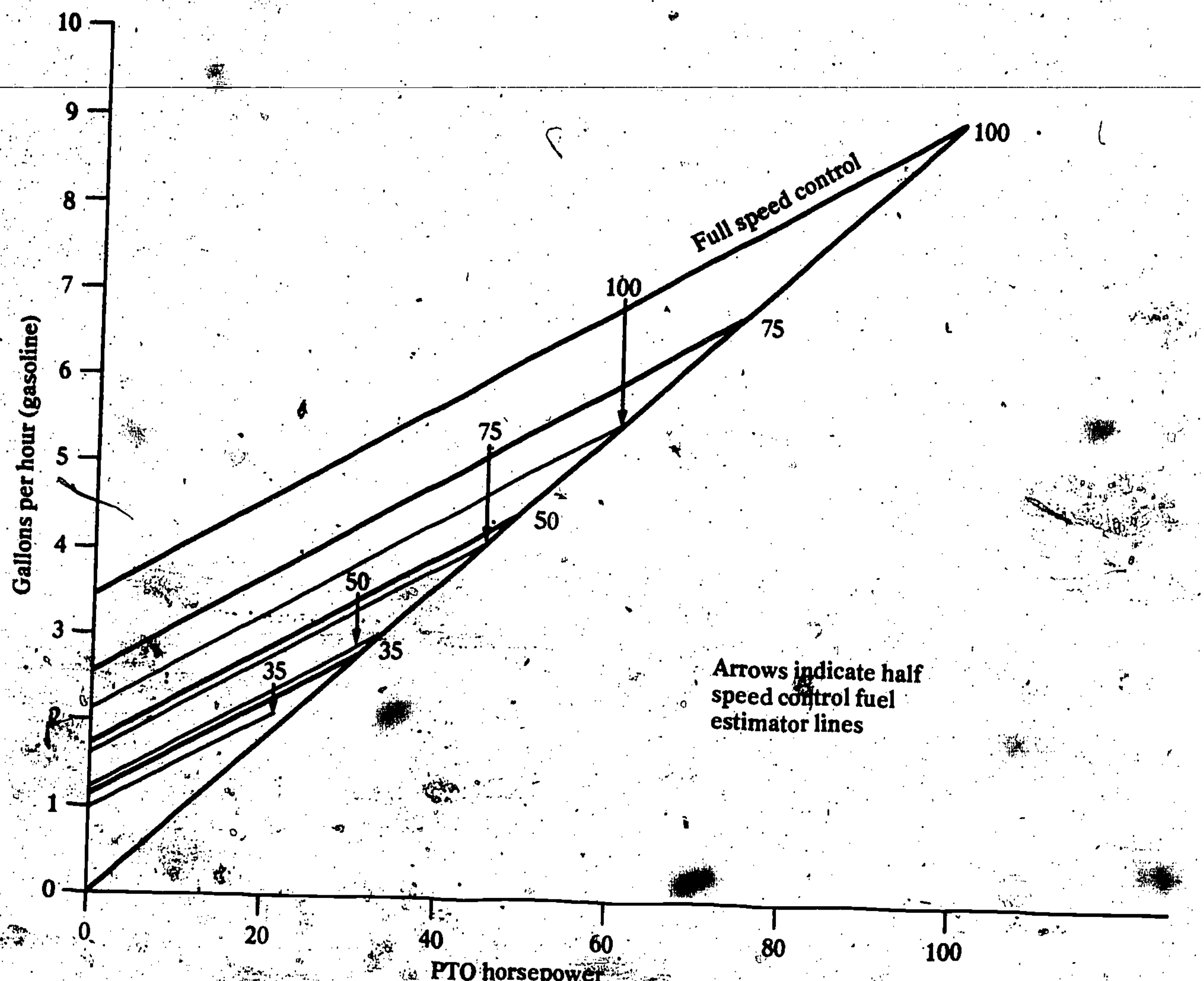

Figure 6. USE OF FUEL PER HOUR BY GASOLINE TRACTORS AT FULL AND HALF ENGINE SPEED AND VARYING POWER DEMANDS

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is uncertain, he checks manufacturer's specifications or calls his dealer. He finds that most pto-operated machines require "standard" engine speed for effective operation and so marks those operations. When standard speed is not a requirement, he marks "variable" to remind him that he has a choice of engine speed. Sometimes a larger tractor operating at reduced engine speed will do a job and with less fuel than a smaller tractor at full engine speed.

Column 5. Best fuel to use--gasoline or diesel. He marks "diesel" for all operations because figures 5 and 6 show that less diesel than gasoline is used per hour at all paired horsepower levels. Some use may have to be made of the gasoline tractor, however, just to keep several operations going at one time.

Column 6. Best size of tractor for each operation. Before deciding this he has to check the power needed to move the tractor (from table 12), but just a glance at the figures he had in column 10 of table 13 is all that is needed to tell that his smallest tractors, the 50-horsepower units, are more than adequate for all jobs except grinding corn and spreading manure. Only the 125-horsepower tractor will handle these two jobs as they are now done.

Column 7. Best engine speed. A 50-horsepower tractor provides enough power with the engine at half speed for those operations allowing a variable engine speed. He discovers this by checking the half speed estimator line for the 50-horsepower tractor in figure 5. He finds that proper machine operation required standard engine speed for all of the other operations.

Column 8. Horsepower to move tractor for mobile operations. He figured this by the same method used in table 13, turning to table 12 for the horsepower data, noting the travel surface recorded in table 13, and speed recorded in table 14.

Column 9. Total horsepower for the operation. He adds the values in columns 2 and 8 of this table.

Column 10. Total tractor hours per year for each operation. He copies this from the estimates he entered in column 12, table 13.

Column 11. The fuel use per hour. All are diesel tractors so he goes to figure 5 and reads the gallons of fuel used per hour opposite the half or full speed estimator lines as appropriate for the horsepower shown for each operation in column 9 of this table. He correctly uses the full speed estimator lines for operations requiring standard engine speed.

Column 12. Total fuel use. He multiplies the values in column 10 by those in column 11.

Total fuel use under the revised combination of tractors and implements is 1,642 gallons of diesel and no gasoline. This would mean a saving of 25 gallons of diesel and 472 gallons of gasoline. Savings were accomplished by substituting diesels for the gasoline tractor, dropping to the 50-horsepower diesel whenever it was adequate to do the job, and reducing engine speed for some of the operations.

Can he manage the work with this combination of tractors and equipment and thus save nearly 500 gallons of fuel? Can he do anything to cut fuel use even more? He has some problems, but he also has several good fuel saving moves that he can make. He approaches the task of finding more ways to save fuel by asking himself some of the old standby questions effective in work simplification. Are there operations that I can eliminate? Combine? Do easier at another time? Simplify? He marks the results of this questioning right on table 14 which he just completed. We have shown them separately in table 15 to clarify the procedure. Let's follow along.

Saving Fuel Through Work Simplification

First, he puts the mower and crimper both on the same tractor. By making one pass over the field to do two jobs, he immediately cuts out 40 hours of tractor time. The 50-horsepower diesel has plenty of power to do both jobs at once. The 23 horsepower to mow and crimp, plus 5 horsepower to move the tractor, makes 28 horsepower total. He lines through the old figures and puts the new ones in. Fuel use for mowing and crimping is now 96 gallons instead of the 152 gallons needed when the operations were separated. There are many chances in farming to combine jobs, and cut both hours and the power to pull the tractor over the field another time.

Fuel use estimates have shown that raking is best done with the 50-horsepower diesel, but he often needs the mower-crimper and rake for use at the same time. He has only one 50-horsepower diesel. Since raking takes the least time--10 hours total--it is the least costly place to use the 50-horsepower gasoline tractor. Horsepower needs are the same, but fuel use per hour increases from 1.1 gallons of diesel to 1.8 gallons of gasoline per hour. He puts the 50-horsepower gasoline tractor on the rake and changes from 11 gallons of diesel to 18 gallons of gasoline.

He can put the baler on one of the 75-horsepower diesels or drop the mower and crimper, and use the 50-horsepower diesel tractor to operate the baler. It takes an extra 0.6 gallon of diesel per hour to run the 75 horsepower diesel with the baler. He has to decide whether saving 12 gallons of diesel fuel is worth the time and effort needed to change the implements on the tractor. This may prove to be impractical, but he chooses for the present to make the implement changes, use the 50-horsepower diesel on the baler and save the fuel.

He usually has to bale and haul hay the same day. The weather risk is too great to wait until baling is done before hauling. He considers it impractical to try to use the 50-horsepower diesel for hauling. He first thought that the 50-horsepower gasoline tractor would be the best substitute, but found the 75-horsepower diesel to be the better choice. At half engine speed the 50-horsepower gasoline tractor takes 2.3 gallons per hour for the needed 19 horsepower; the 75-horsepower diesel 1.9 gallons per hour for the needed 22 horsepower. He replaces the 50-horsepower diesel with one of his 75-horsepower diesels for hauling. This costs him only 8 gallons of diesel fuel more than the 50-horsepower diesel would have taken, and avoided a three-way change of implements on the one 50-horsepower diesel tractor.

He could put a smaller tractor using less fuel per hour on the hammer mill used to grind corn, but it would only take more time to do the job. Total fuel use would not change appreciably. A coarser grind would cut power needed, but he already uses a rather coarse grind. He found the real question to be what the grinding of shelled corn contributed to the feeding of the cattle, especially since it took 320 gallons of diesel fuel. What has long been an accepted necessity, perhaps supported at one time by some research, may well be subject to change as a result of new research findings. That was the case with grinding. He learned that research now shows that cattle perform equally well on dry shelled corn whether it be fed whole or ground. He thus quit grinding corn and eliminated the use of 320 gallons of diesel fuel.

The daily chore of distributing feed to the cattle took 195 gallons of diesel fuel. He knew this was a necessary job, but asked himself whether it could be improved. He had his feed bunks inside the lot. Opening gates, competing with cattle, moving bunks and losing time at the turns took half the time in feeding, according to a research report that he read. By installing fence line bunks he could expect to cut tractor time per year from 150 to 75 hours. Then, with a rock road along the bunks, he could improve the travel surface from "fair" to "good" thus reducing the power needed to move the load and tractor from 14 horsepower to 6 horsepower. The change of real significance was the saving of 75 hours, but everything added up to cutting diesel fuel for feeding from 195 to 68 gallons a year.

He found no way to improve the manure loading job, but he saw the 480 gallons of diesel fuel used for spreading manure as a formidable amount--almost a third of the total after he rematched the tractors and equipment. Could anything be done to reduce fuel use? Perhaps. Operation of the spreader took only 4 horsepower, but moving the tractor and loaded spreader over soft ground took 115 horsepower and accounted for most of the fuel use. He decided to try to improve the travel surface from "poor" to "fair" by leaving the spreading area unplowed, waiting until the ground dried to a firm surface, perhaps even making some shifts in the cleaning and spreading time period. A "fair" surface would reduce hauling power needed by 40 percent and, through planning, this was his goal. Then he could use one of the 75-horsepower diesels needing only 62-horsepower total--4 horsepower to run the spreader, 34 horsepower to haul the 7 tons and 24 horsepower to move the tractor. Fuel use per hour dropped from 8.0 to 4.4 gallons; total requirement was now 264 gallons instead of 480 gallons.

He had first reduced fuel for miscellaneous work and travel from 380 gallons of gasoline to 240 gallons of diesel simply by using the 50-horsepower diesel instead of the 50-horsepower gasoline tractor. Now he wondered about that 200 hours on the hourmeter. Everyone gets into some wasteful habits in their chores and general farm work. Examine the routine and plan ahead for least waste of tractor time. Eliminate unnecessary jobs, don't back track, and combine several jobs into one trip. He believes that with some thought and systematic planning he can cut miscellaneous tractor time down to 100 hours and 120 gallons of diesel fuel.

He also thought about using a few sheep to eliminate the weed clipping chore. However, he decided to leave the weed clipping job alone.

Total fuel use per year is finally reduced to 800 gallons of diesel fuel and 18 gallons of gasoline (table 15). That is less than half the diesel fuel used in the present operation and almost eliminates use of gasoline. All operations are being effectively carried out, the cattle perform as well as before, and no change has been made in the complement of tractors and implements, although when it is the next time to trade tractors strong consideration should be given to replacing the gasoline tractor with a diesel unit. Along with these fuel savings wil[illegible] some significant reductions in as[illegible]d tractor and implement costs, such as repairs, oil, and grease, and especially the labor input. Also, the feed mill is no longer needed.

Table 13--Livestock production: Variables used to estimate tractor fuel use in finishing 350 steer calves in drylot, crop-livestock farm

(1) Operation	(2) Tractor used (horsepower)	(3) Fuel used	(4) Engine speed used	(5) Travel surface	(6) Travel speed (miles/h)	(7) Implement weight loaded (tons)	(8) Horsepower used to-- Operate implement	(9) Horsepower used to-- Move implement	(10) Horsepower used to-- Move tractor	(11) Total horsepower used--all operations	(12) Operating hours per year	(13) Fuel use (gallons) Per hour	(14) Fuel use (gallons) Per year Diesel	(15) Fuel use (gallons) Per year Gasoline
Mow	50	G	Standard	good	5	1	4	2	5	11	40	2.3	---	92
Crimp	125	D	Standard	good	5	2	14	3	10	27	40	4.0	160	---
Rake hay	75	D	Half	good	5	1	3	2	7	12	10	1.5	15	---
Bale hay	75	D	Standard	good	4	2	15	2	6	23	20	2.7	54	---
Haul hay	50	D	Full	good	8	5	0	11	8	19	20	2.0	40	---
Grind corn	125	D	Standard	good	0	0	81	0	0	81	50	6.4	320	---
Feed cattle	75	D	Full	fair	2	4	1	7	8	16	150	2.4	360	---
Load manure	75	D	Full	fair	2	2	6	4	8	18	60	2.5	150	---
Spread manure	125	D	Standard	poor	6	7	4	57	58	119	60	8.0	480	---
Clip weeds	50	D	Standard	fair	5	1	6	4	14	24	40	2.2	88	---
Misc. travel	50	G	Half	good	10	1	0	3	9	12	200	1.9	---	380
Total	---	---	---	---	---	---	---	---	---	---	690	---	1,667	472