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ABSTRACT

This booklet gives a brief overview of energy use in poultry operations and gives examples of cutting costs of brooding, lighting, ventilation, feeding, watering, waste removal, housing design, construction and maintenance. Finally, energy use recordkeeping is discussed. (BB)

A GUIDE TO ENERGY SAVINGS

FOR THE POULTRY PRODUCER

UNITED STATES
DEPARTMENT OF
AGRICULTURE

FEDERAL
ENERGY
ADMINISTRATION

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

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

Other publications in this series are *A Guide to Energy Savings for the Vegetable Producer*, *A Guide to Energy Savings for the Livestock 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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* Listing does not imply official action to endorse the report nor complete agreement with its contents.

JUNE 1977

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The Nation's 2-1/2 million farms consume 6.3 billion gallons of gasoline and diesel fuel, some 173 billion cubic feet of natural gas, 1.5 billion gallons of LP (liquified petroleum) gas, and 32.3 billion kilowatt-hours of electricity in a typical year.

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

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

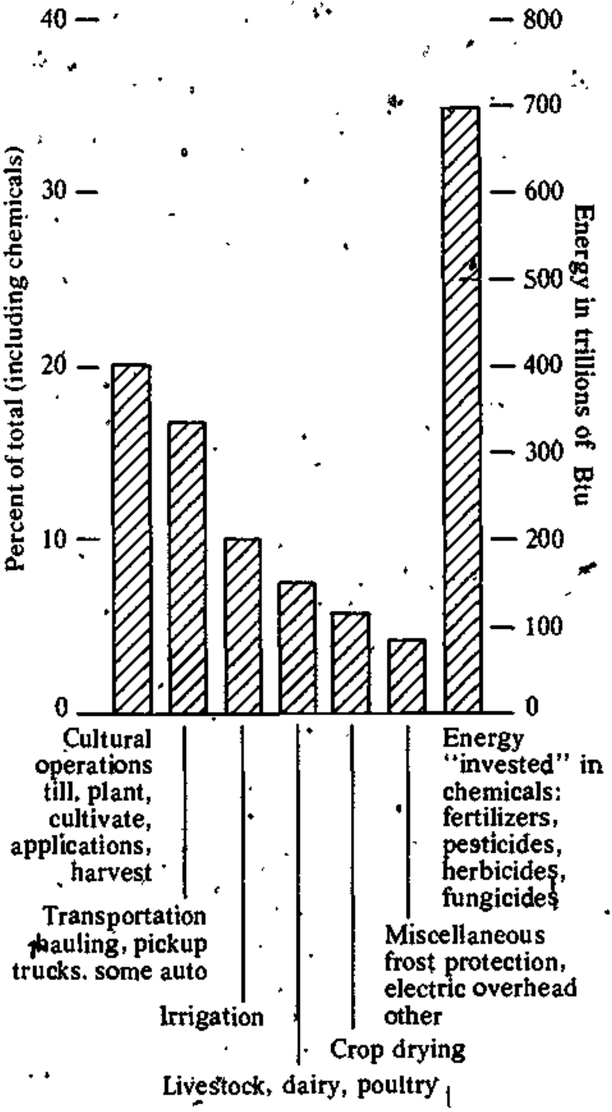


Figure 2.1 ENERGY USED IN AGRICULTURE, PLUS FERTILIZER AND CHEMICALS (1974)

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.

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 use energy resources even more prudently in the future.

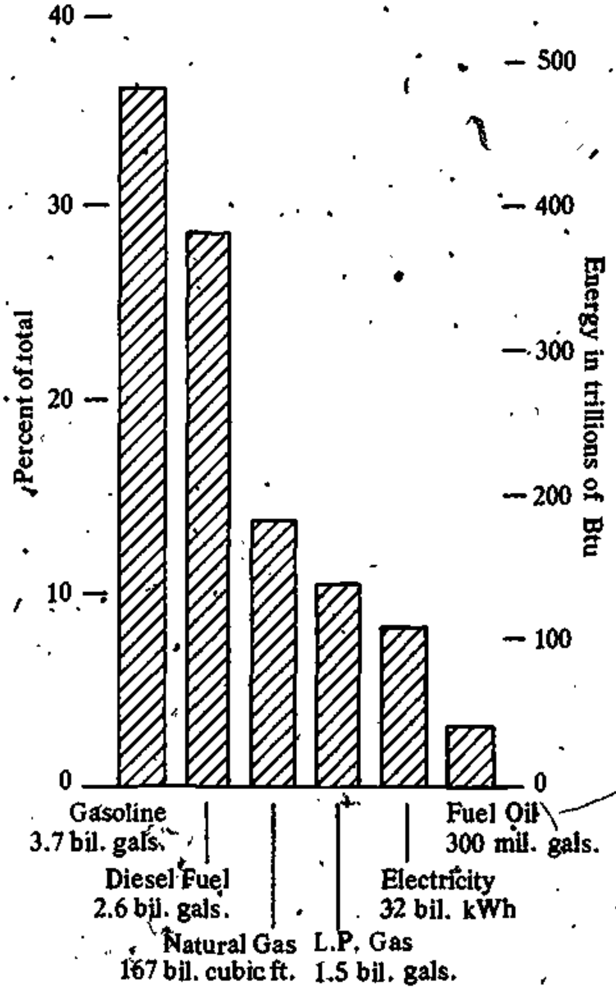


Figure 1. ENERGY USED IN AGRICULTURE (1974)

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

Commodity	Inventory 2/ 3/ (head)	Gasoline (gallons)	Diesel (gallons)	Fuel Oil (gallons)	LP gas (gallons)	Natural gas (cubic feet)	Electricity (Kilowatt-hours)	Invested energy 4/ (Btu)	Total energy 5/	Energy per 1,000 head (Btu)
	Thousands					Millions		Billions		Thousands
Layers	286,478	13,966	1,760	522	5,090	249	829	NA	5,639	19,684
Pullets	285,622	22,680	893	1,206	23,556	545	14	NA	6,146	21,518
Broilers	2,990,938	23,214	---	6,397	122,274	2,237	504	NA	19,974	6,678
Turkeys	131,310	9,994	1,578	479	42,395	1,162	67	NA	7,174	54,634
Misc. poultry	NA	1,482	---	213	1,559	424	2	NA	854	NA
Total poultry	NA	71,336	4,231	8,817	194,874	4,615	1,415	NA	39,787	NA
Other livestock	NA	746,029	348,185	---	138,011	10	8,613	NA	184,504	NA
Total livestock	NA	817,365	352,416	8,817	332,885	4,625	10,028	NA	224,291	NA
Total crops 6/	340,596	2,881,276	2,286,539	295,112	1,148,657	159,500	22,060	716,452	1,789,930	5,255 7/
Total agriculture	NA	3,698,641	2,638,955	303,929	1,481,542	164,125	32,088	716,452	2,014,221	NA

NA = Not applicable.

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/ Hens represent average number of layers (1,000). Turkeys, broilers, chickens represent number raised (1,000).

4/ Invested energy includes the energy required to manufacture fertilizers and pesticides (including carrier solution).

5/ Poultry energy use includes some energy derived from coal.

6/ Thousand acres.

7/ 1,000 Btu per acre.

In 1974, poultry production used nearly 34 trillion Btu (British thermal unit). One Btu is the heat required to raise the temperature of 1 pound of water from 62°F. to 63°F. Figure 3 shows how this energy was used. The percentages will vary with the type of poultry. So will the sources of energy: electricity, heating fuels, and motor fuels. (To determine the amount of Btu consumed in a month or a year on a particular farm, see the conversion chart on page 44.)

Table 2 shows the U.S. average quantity of each type of fuel used per thousand birds for broilers, turkeys, layers, and layer replacements. Energy use of a specific producer may vary considerably from the U.S. average since many types of operations and locations were combined to estimate these rates.

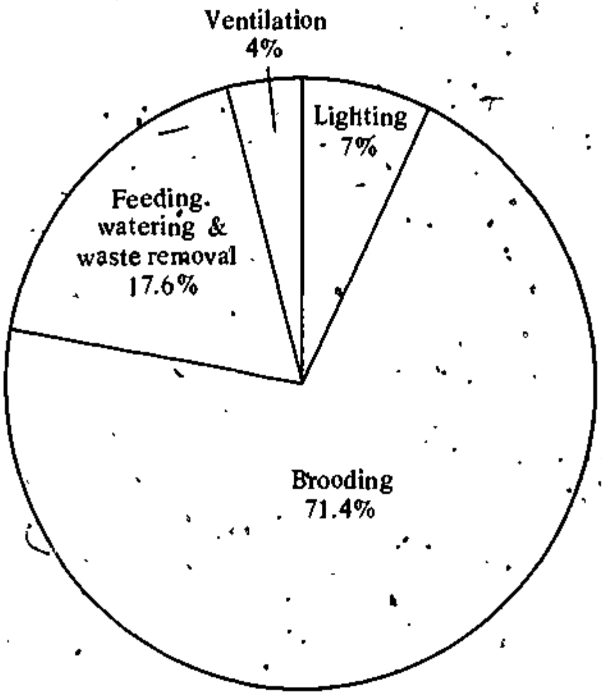


Figure 3. PERCENT OF THE BTU ENERGY USED IN POULTRY PRODUCTION THAT IS USED BY VARIOUS FUNCTIONS

Table 2--U.S. average energy use per 1,000 birds in 1974 1/

Type of poultry	Gasoline & diesel fuel	Electricity	Fuel oil	LP gas	Natural gas	Coal
	Gallons	Kilowatt-hours	Gallons		Cubic feet	Tons
Broilers	2.0	162	38.5	45.3	11,888	0.36
Turkeys 2/	49.2	479	209.8	379.6	51,232	1.95
Hens 2/	40.0	2,912	20.2	22.5	7,588	0.00
Chickens 3/	23.1	50	84.3	100.8	18,810	0.83
Other poultry 4/	20.0	30	52.0	106.2	49,377	0.97

1/ To determine the number of Btu used per 1,000 birds, convert the units (gallons, etc.) into Btu, then add the Btu in column 1 to the Btu in column 2 and the Btu under one of the fuels in column 3 (since poultry producers generally use only one type of heating). Btu conversion table on page

2/ Includes breeders.

3/ Mainly laying flock replacements, but includes some nonbroiler meat chickens.

4/ Ducks, geese, guineas, game birds, etc.

9

Savings attained from such fuel conservation measures as additional insulation, winterizing side curtains, proper equipment maintenance, reduced lighting levels, changes in lighting patterns, partial house brooding, improved ventilation practices and improved waste removal practices will vary among producers from as much as 20 to 50 percent. The extent of the potential saving will vary considerably from producer to producer. For example, a recent local survey in a broiler production area found some broiler producers using twice as much fuel as others in the same area.

Broiler Industry

The ability of broiler growers to adopt new practices depends partially on economic incentives and capabilities.

A broiler grower, for example, may have two houses, each capable of housing 15,000 broilers. These broilers are likely to be grown under contract for an integrated broiler operation with the grower receiving 2 to 3 cents a pound as his payment for providing the house, the electricity, possibly the fuel, and the labor.

Assuming he grows five flocks annually, his gross revenue will approximate $15,000. His energy costs could vary from under $2,000 to over $4,000 depending on the building construction, insulation, and management practices.

Egg Industry

In the egg production industry, layer replacement raising is similar to a broiler operation in that brooding may consume the most energy. The total farm energy costs for a 40,000 bird replacement per year farm could range from under $1,500 to over $3,000.

Most of the energy costs for an egg producer result from electricity used for lighting, ventilation, feeding, and egg collection. Total energy costs for an egg producer with 30,000 layers could range from under $3,000 to over $5,000.

Turkey Industry

Although turkeys are usually range reared, there is a trend toward full confinement which requires more energy for space heating, ventilation, and manure removal. Adoption of energy conservation practices in housing design should help develop an energy efficient industry.

Other Poultry

Energy use in raising ducks, geese, guineas, pheasant, and other poultry is relatively small because of the limited scope of these activities. However, potential savings in energy use for brooding 1,000 birds are similar to savings for broilers, pullets, and turkeys, except in cases where the offspring are hatched and brooded by parent birds. Ventilation and related conservation practices in construction would be applicable in confinement rearing.

BROODING

Over 71 percent of the energy used in poultry production is consumed in brooding, so management and maintenance in this area demand close attention.

Adoption of the following energy conservation measures could lead to substantial fuel savings.

1. Adherence to good general brooding management practices and good brooder maintenance could save at least 10 percent.

2. Partial-house brooding could save 25 percent or more.

3. Winterizing the side curtains could save 10 to 15 percent.

4. Shutting off half of the brooder pilot lights, when all brooders are no longer needed, could save as much as 10 percent.

Although these savings are not additive, they could result in total fuel savings of as much as 50 percent.

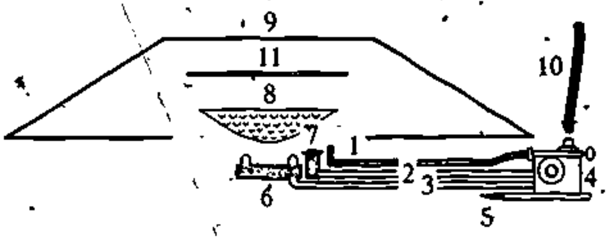
Energy Tips for Operation and Management

Brood the maximum number of chicks feasible per brooder. Brooder capacity can be increased by 10 to 20 percent by clustering the brooders in groups of three or four and using a single brooder guard per cluster.

Start and maintain chicks on dry litter (20 to 30 percent moisture content). Wet litter uses heat to evaporate moisture. Leaking water systems require additional heat to evaporate spilled water.

Locate brooders near the center of the house to reduce heat loss through building walls and possible drafts through curtains or air intakes.

Set up solid brooder guards made of materials such as sheet metal or corrugated paper to help hold in the heat as well as the chicks.



1. Thermocouple
2. Pilot gas supply line
3. Main gas line to gas jets
4. Control unit
5. Temperature sensing element
6. Gas jets
7. Pilot light
8. Ceramic element
9. Canopy
10. Gas hose
11. Heat baffle

Figure 4. GAS BROODER DIAGRAM

Brood at the lowest temperature consistent with bird comfort. A starting temperature of 85°F. is acceptable for most conditions. Reducing the brooding temperature by 2°-3°F. every 3-4 days instead of 5°F. every week can save money.

Check brooder thermostats frequently for accuracy to avoid wasting fuel and causing chick stress.

Start layer replacement chicks that are in cage houses in the top deck where room temperature is highest.

Examine brooder gas lines and hoses for leaks before each brood.

Use only special gas hose on brooders to prevent leaks.

Maintain gas line pressure at a specified pressure of an 11-inch water column. Valves should be fully opened when gas is in use. More than one size of gas line may be required to maintain the prescribed pressure in long gas lines.

Be sure pilot lights are adjusted according to the manufacturer's specifications.

Keep the burner orifice clean. Use the proper size reaming needle. Be careful not to alter the orifice size.

EXAMPLE OF CUTTING COSTS BY PARTIAL HOUSE BROODING

$317.27 savings for a farmer who produces	80,000 broilers per year

During the first 3 weeks of brooding, 4 mil polyethylene curtains can be used to partition off the middle of the broiler house as shown in figure 5. Day-old chicks are placed in the center section of the building at twice the normal number per brooder. The full number of feeder lids and waterers must be maintained. Equipment should be in place before arrival of the chicks since the higher chick numbers per square foot make equipment changes difficult. Curtain partitions should be removed at 3 weeks allowing the broilers to distribute themselves throughout the house. Extending the time poses litter caking and feeding problems (15). 1/

Advantages of the system are:

1. More uniformity in brooding temperature
2. Less draft in brooding area
3. More time for grower between flocks to set up the remaining sections of the broiler house.

One brooder in each end of the house should be on at a low setting to prevent water from freezing.

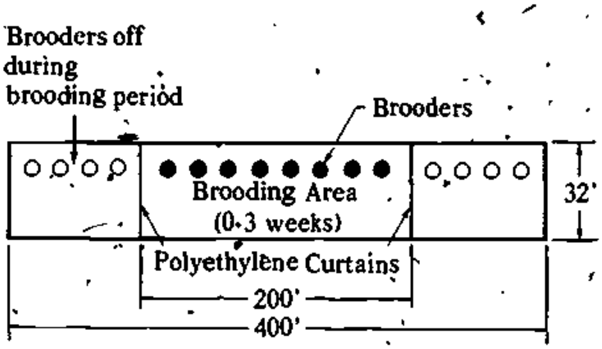


Figure 5. PARTIAL HOUSE BROODING SYSTEM

Example: A Maryland broiler grower produces 5 flocks of 16,000 birds per year for a total of 80,000 birds. He has one 32 by 400 foot conventional broiler house which has a 7 foot ceiling height.

Assume the following: (1) The grower attaches the curtain partitions to the ceiling and maintains them in place for 3 weeks. (2) The grower charges $3 per hour for his installation and maintenance labor. (3) The grower uses 4 mil polyethylene curtains at a cost of 1 cent per square foot. (4) The 5 flocks are placed in January, March, May, July, and September.

Using the following labor and factor cost estimates, the total net saving of $317.27 is calculated as follows:

<u>Labor use and factor cost estimates</u>

Installation labor - 4 hours
Maintenance labor - 1 hour per flock
LP gas - 30 cents per gallon
Lath - $5 per bundle
Other materials - $5

1/ Numbers in parentheses refer to References at the end of this guidebook.

Estimated Installation Cost			Maintenance
Labor	-	$12.00	$3 per flock
Curtain	-	4.48	
Lath	-	5.00	
Other materials	-	5.00	
Total		$26.48	

Estimated Annual Cost = $26.48 ÷ 3 years + $15 ($3 x 5 flocks per year) = $23.83

The fuel savings are estimated by multiplying the estimated LP gas consumption for a flock placed in January, 97 gallons, by the estimated portion of fuel used during the first 3 weeks, 0.75, when partial brooding is used. This is multiplied by 0.40, the estimated reduction in building heat loss due to partial house brooding, to arrive at the estimated fuel savings per 1,000 birds. The LP savings per flock of 16,000 broilers is shown in table 3 as 466 gallons. At 30 cents per gallon this equals $139.80 for the January flock. Total saving for all flocks is $341.10 per year. Subtracting the annual cost, $23.83, gives a net savings of $317.27 for the year.

Table 3--Estimated fuel savings per flock

Month started	Portion of fuel consumed 1-3 weeks		LP use rate per 1,000 birds (gallons)		No. of birds (thousands)		Reduced heat loss factor		Savings of LP per flock (gallons)		LP cost per gallon (dollars)		Savings per flock (dollars)
Jan.	.75	x	97	x	16	x	.40	=	466	x	.30	=	$139.80
Mar.	.90	x	67	x	16	x	.40	=	386	x	.30	=	115.80
May	1.00	x	24	x	16	x	.40	=	154	x	.30	=	46.20
July	1.00	x	6	x	16	x	.40	=	38	x	.30	=	11.40
Sept.	.85	x	17	x	16	x	.40	=	93	x	.30	=	27.90
Totals									1,137				$341.10

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual savings	$260.42	$317.27	$374.12	$430.97

EXAMPLE OF CUTTING COST BY WINTERIZING A CONVENTIONAL BROILER HOUSE

$235.10 savings for a broiler grower who produces 90,000 broilers per year

Heat loss through broiler house side curtains may be reduced by 50 percent through winterizing (figure 6). To winterize, a layer of polyethylene should be tacked to the inside of the side window opening to reduce air leakage. However, the reduction in air movement may require installation of additional fans to provide proper ventilation rates.

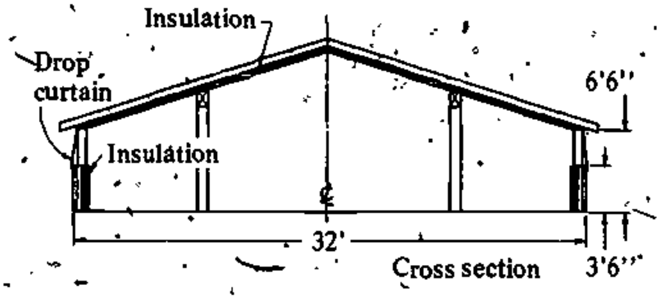


Figure 6. DIAGRAM OF INSULATED BROILER HOUSE WITH SIDE CURTAINS

Example: A grower produces 90,000 broilers per year in two 32 by 200 foot houses. The houses have 3 foot side curtains running the length of the house. Assume that he winterizes his side curtains by installing the polyethylene over the window opening for 3 flocks placed in September, January, and March and uses the curtain for one season.

The estimated net savings is calculated below and shown in table 4. The fuel savings is based on LP gas at 30 cents per gallon.

The fuel savings per house is based on the inside and outside temperature difference shown in table 4. The temperature difference is multiplied by the heat loss reduction factor (648 Btu per hour per degree difference) to obtain the Btu savings per hour.

This is then multiplied by 24 hours per day 7 days per week, and 6 weeks per flock to estimate total Btu savings per flock. This assumes no heat is used after 6 weeks of age. The Btu savings is divided by the Btu per gallon of LP gas to give the LP gas saving. See example calculation for January and fuel saving table 4.

$$39^{\circ}F. \times 648 \frac{Btu}{(hr)\ (degree\ difference)} \times 24\ hr/day \times 42\ days \div 92{,}000\ Btu/gal = 276.9\ gal$$

The total fuel savings based on LP gas at 30 cents per gallon for both houses is $323.76. The estimated cost is $88.66 for a net savings of $235.10 for a 90,000 broiler per year operation, less additional cost of installing and operating fans if required.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual savings	$181.14	$235.10	$289.06	$343.02

Table 4-- Estimated fuel savings per house, specified months

Month	Mean outside temp. (degrees F)	Inside temp. (degrees F)	Difference inside-outside (degrees F)	Fuel savings (gallons) 1/	Dollar savings
Sept.	69	75	6	42.6	12.78
Jan.	36	75	39	276.9	83.07
Mar.	44	75	31	220.1	66.03
Total				539.6	$161.88

1/ Collins, N.E. and Walpole, E.W. show a difference in heat loss due to winterizing side curtains of 648 Btu per hour per degree Fahrenheit difference between inside and outside temperature (20).

Annual Cost Estimate Per House

1200 ft^2 of plastic	$12.00
Labor (8 at $3.00/hr)	24.00
Lath (5 bundle $5 each/3 yr life)	8.33
	$44.33

EXAMPLE OF CUTTING COSTS BY TURNING OFF HALF THE PILOT LIGHTS AFTER THE FIRST 3 WEEKS

Demand for supplemental heat from brooders decreases rapidly in the latter weeks of production. If the pilot lights on half of the brooders were shut off and only relit during severe weather, a fuel savings of as much as 10 percent might be attained. The potential savings may be diminished somewhat from those shown in the following example since some of the heat given off by the pilot lights is effectively used to heat the house.

In some climates and in poorly insulated overventilated houses, it may be necessary to have all brooders on for longer than 3 weeks to maintain a healthy environment for the chicks.

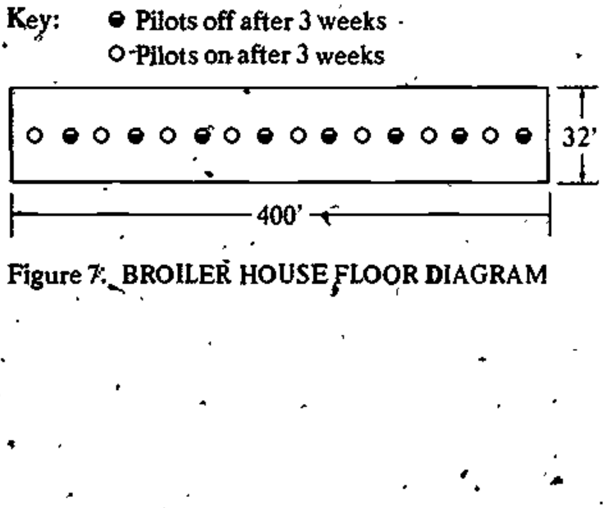


Figure 7. BROILER HOUSE FLOOR DIAGRAM

$132 savings per year from turning off half the pilot lights the 4th through 8th weeks of production for an 80,000 broiler farm

Example: A broiler producer has one 32 by 400 foot broiler house. He produces 5 flocks of 16,000 birds each per year for a total of 80,000 broilers. He has 16 brooders in his broiler house. Assuming his pilot light uses 1,200 Btu per hour (brooder pilot light fuel use varies widely, this is only an estimate) the total Btu use over 5 weeks for 8 brooders would be 8,064,000 Btu. This is equal to at least 88 gallons of LP gas per flock. At 30 cents per gallon the annual savings for the 5 flocks would be $132. No costs are subtracted since no materials and little if any additional labor would be required.

The calculations follow: Btu per flock = 1,200 Btu per brooder/hour x 24 hour/day x 7 day/week x 5 weeks x 8 brooders = 8,064,000 Btu.

Gallons per flock = 8,064,000 Btu ÷ 92,000 Btu/gal of LP gas = 88 gal
Estimated total savings per year = 88 gal of LP gas/flock x 5 flocks x $.30/gal of LP gas = $132.

In this example it is assumed that the grower did not previously shut off his brooders during the entire production period. If all brooders and pilot lights are shut off after the first 6 weeks or less, potential savings will be approximately half those shown.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual savings	$110	$132	$154	$176

LIGHTING

About 7 percent of the energy used in poultry production is for lighting. Yet, lighting use in some cases can be cut in half. Turn off lights when they are not needed. One 150-watt bulb left on overnight (12 hours) consumes 1.8 kilowatt hours (kWh) per night. Over a year this could add $20 to an electric bill.

Extended life lamps are more economical to the user in some situations, even though the lumen output is 10 to 15 percent less. The light output of a bulb is measured in lumens, and the amount of electricity used in watts. A foot-candle indicates the lumens that fall on 1 square foot of surface.

With aid of a simple light meter and the following tabulation a poultryman can match the amount of light provided to tasks performed in that area.

Energy Tips for Operation and Maintenance

Use the right bulb, clean fixtures, and eliminate unnecessary lights. Substitution of one 100-watt incandescent bulb for two 60-watt bulbs achieves a 16 percent energy saving and provides approximately the same light.

Replace dim bulbs, especially wornout fluorescent bulbs, because their efficiency drops rapidly.

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

Remove unnecessary lamps, especially in rooms where all lights operate off one switch. If you are removing a fluorescent lamp, disconnect the primary side of the ballast, because the ballast draws energy even after the removal of the lamp. When removing lamps from a work area, remove them from behind, rather than from in front of the work area. This keeps the work area free of shadows.

Recommended Illumination Levels

Area or visual task	Foot-candles
Feeding, inspection, and cleaning	20
Reading charts and records	30
Preparing and processing feeds	10
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: Adopted from (27), pp. 10-12.

Planning

Consider lighting efficiency when removing or building a new poultry house.

Use fluorescent instead of incandescent bulbs wherever possible indoors (they provide about four times as much light per unit of energy used). For outdoor lighting, a mercury vapor lamp provides more than twice as much light as incandescent light per unit of energy used; high pressure metal halide 4 times and high intensity discharge sodium 5 times as much light. Consider, however, that a mercury vapor lamp has a 3-10 minute startup time and 5-10 minute delay before restarting. High pressure sodium color rendition is equal to clear mercury and is acceptable. For best color appearance use metal halide or deluxe mercury. Consult an extension poultry scientist when changing the type of lighting. The color of light emitted may be as important as levels of light.

Consider lower light intensity for broilers and layers. While difficult to observe birds and equipment, lowering light intensity to 0.5 foot-candle not only reduces electricity use but eliminates the need for debeaking (added dollar and energy savings).

Table 5--Average lumens (light output) per lamp 1/

Type of lamp	Size by watts	Average output in lumens	Average hours of life	Average lumens per watt 1/
Incandescent (standard)	25	225	750 to 1,000 2/	9
	40	430		11
	60	810		14
	100	1,600		16
	150	2,500		17
	200	3,500		18
	300	5,490		18
Fluorescent (standard)	15	660	18,000	34
	20	1,000		40
	40	3,200		60
Mercury (clear)	75	2,800	24,000	
	100	3,800		
	175	7,900		40
	250	11,600		45
	400	21,000		50
	700	39,000		
Metal halide	175	12,000	15,000	75
	400	34,000		
	1,000	95,000		
Sodium (high-pressure)	250	25,500	16,000	100
	400	47,000		
	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: See (21), p. 190.

EXAMPLE OF CUTTING COSTS THROUGH GOOD LIGHTING MANAGEMENT 2/

$311.75 savings per year attributed to good light management for a 5,600 layer farm

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

If rows of lights are staggered, the light distribution is improved and the number of bulbs required to light the area is reduced slightly. The distance between bulbs should be about one and one-half times the distance from the light to the floor depending on ceiling height. The distance from the wall should be equal to half the distance between the bulbs.

Example: An egg producer has one 40 by 250 foot conventional floor house for 5,600 layers. He has a schedule with 14 hours of light and 10 hours of dark. The house has a 10-foot ceiling height. Assume that enough lights are mounted on the ceiling to provide at least 1 foot-candle of light at the floor level. The following calculations will show the energy savings which can be attributed to cleaning lights and using reflectors. For the purpose of this comparison, assume that lights are installed to maintain a minimum of 1 foot-candle even when the bulbs are dirty. Three parallel rows of lights are required with 17 60-watt incandescent bulbs per row. The kilowatt-hour usage per year is calculated below.

51 bulbs x 60 watt/bulb x 14 hours/day x 365 days/year ÷ 1,000 watt-hours/kWh = 15,636.6 kWh year.

At 4 cents per kilowatt-hour the total cost if $625.46. If the bulbs were replaced with clean 40-watt bulbs, the total kilowatt-hour per year would be reduced to 10,424.4 kilowatt-hours. At 4 cents per kilowatt-hour the total cost annually is $416.98 for gross savings of $208.48 per year. Assuming 1 hour per month is required to clean the bulbs, the annual labor cost at $3 per hour would be $36. The total estimated annual net savings is $172.48.

If the clean 40-watt bulbs were replaced with clean 25-watt bulbs with aluminum foil reflectors (pie tins might be used), the total kilowatt hours per year would be reduced to 6,515.2 kilowatt-hours. At 4 cents per kilowatt-hour the total annual cost is $260.61 for an additional gross savings of $156.37 per year. At 10 cents per reflector and assuming that it takes 4 hours to install the reflectors, the total cost at $3 per hour is $17.10. The total estimated annual net savings is $139.27.

Total net savings possible, if both light management practices are initiated, is $172.48 + $139.27 = $311.75.

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$220.54	$311.75	$402.97	$494.19

2/ Adapted from (26) and (29).

EXAMPLE OF CUTTING COSTS BY ADOPTING A REDUCED LIGHTING SCHEDULE

$292 savings from adopting a reduced lighting schedule on a 30,000 layer house

A recent experimental lighting program developed by A. van Tienhoven and C.E. Ostrander has some energy conservation potential. The light program has been tested commercially only on a limited scale. It is estimated that changing the layer lighting schedule from 14 hours of light and 10 hours of dark to 8 hours of light, 10 hours of dark, 2 hours of light, and 4 hours of dark in environmentally controlled housing could reduce lighting kilowatt-hours from 852 to 608 a year per 1,000 layers or nearly a 29 percent reduction.

At 4 cents per kilowatt-hour, this is a saving of $9.76 per 1,000 layers each year. An additional factor to consider is that, although the new lighting schedule did not significantly improve egg production or quality, it did just as well and possibly better than the traditional lighting schedule.

WARNING: If this lighting program is used, start it at the beginning of the laying cycle. Do not switch a flock to this program when it is well into production. In addition, make sure that the fans are light trapped. (Light trapping of fans may necessitate longer running time or additional fans to overcome the added resistance.)

Example: A layer producer has one 30,000 bird house which is assumed to be lighted by 250 20-watt light bulbs. If a 14-hour light and 10-hour dark schedule were followed, the house would use 25,550 kilowatt-hours per year. If the 8 hours of light, 10 hours of dark, 2 hours of light, and 4 hours of dark were followed, the house would use 18,250 kilowatt-hours per year. The net savings is 7,300 kilowatt-hours per year or $292 at 4 cents per kilowatt-hours.

250 bulbs x 20 watts/bulb x 14 hours/day x 365 days/year ÷ 1,000 watt-hours = 25,550 kWh per year

250 bulbs x 20 watts/bulb x 10 hours/day x 365 days/year ÷ 1,000 watt-hours = 18,250 kWh per year.

Net Energy Savings = 25,550 kWh - 18,250 = 7,300 kWh

Net Dollar Savings = 7,300 kWh x $.04/kWh = $292

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual Savings	$219.00	$292.00	$365.00	$438.00

EXAMPLE OF CUTTING COSTS BY LOWERING LIGHT INTENSITY

$153.20 savings for a grower who produces 70,000 broilers per year

There are potential savings in lowering light intensity for broilers and layers. Recent studies indicate that light intensity can be lowered to approximately 0.5 foot-candle. This not only reduces electricity use but eliminates the need for debeaking (added dollar and energy savings). However, the low level lighting makes it difficult to observe birds and equipment.

Example: A broiler grower has one 40-by 280-foot environmentally controlled broiler house. He produces 5 flocks annually for a total of 70,000 birds. Assume that the house is lighted by 69 25-watt incandescent bulbs (1 to 2 foot-candles). If he installs a solid state dimmer at a cost of $125 and reduces the lighting to 0.5 foot-candle, the effective wattage required per bulb would be 5-10 watts. The lighting cost for each alternative, assuming 24-hour lighting and electricity costs of 4 cents per kilowatt-hour as calculated and also the estimated total savings as follows:

Before dimming

69 bulbs x 25 watts/bulb x 24 hours/day x 56 days/flock ÷ 1,000 watt-hours = 2,318 kWh/flock

After dimming

69 bulbs x 10 watts/bulb x 24 hours/day x 56 days/flock ÷ 1,000 watt-hours = 927 kWh/flock

Savings per flock in kWh = 2,318 kWh/flock - 927 kWh/flock = 1,391 kWh/flock

Total dollar savings per year = 1,391 kWh/flock x $0.04/kWh x 5 flocks/year = $278.20

If the total cost of the dimmer switch ($125) were subtracted the first year, there would still be a net savings of $153.20. The dimmer should last considerably longer than 1 year. It may be beneficial to have a bypass switch installed near the dimmer to allow the grower to turn the lights on to full power without adjusting the dimmer.

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual Savings	$ 83.65	$153.20	$222.75	$292.30

VENTILATION

Ventilation accounts for about 4 percent of the energy used in poultry production. But there are wide variations because of differences in climate and ventilation systems. A side curtain poultry house may be ventilated entirely without the use of fans, requiring no electrical energy, but the disadvantages of heat loss in cold months and heat stress in hot months encourage some kind of environmental control using energy.

The proper ventilation rate depends on the type and age of the birds, method of handling manure, inside and outside temperatures and humidity, and the incidence of gases. In many cases, ventilation/for proper moisture level in the litter and desired temperature will also remove gases. An exception may occur in the first week or two of brooding when a dangerous gas buildup could occur.

Energy Tips

Consider these factors when selecting a fan or system:

Air volume (cubic feet per minute, or ft^3/min)

Air velocity (feet per minute, or ft/min)

Static pressure of system

Performance curves or charts

Intended location

Cleanability

Noise

Types and locations of air intakes

Temperature controls and placement

Housing

Motor

Shutters

Guard

EXAMPLE OF CUTTING COSTS BY SELECTING THE MOST ECONOMICAL VENTILATION SYSTEM

$435.50 savings for a 6,000-layer farm

Poultry house fans should be rated at 1/10-inch static pressure with free air delivery. They should be the nonoverloading type with good efficiency in cfm/watt. Motors should be totally enclosed and should have permanently lubricated ball bearings, built-in overload protection with nonautomatic resetting 3/, low starting current, and a high power factor. Both should be made of heavy-gauge metal with tough weather-and-corrosion-resistant finish.

The best way to learn about fan performance is from a reputable manufacturer's test data. Any particular fan blade, driven at a constant speed, can be most efficient for only a narrow range of air deliveries. Once a fan is designed for maximum efficiency, the manufacturer will usually list its most practical speed. Besides fan wheel size, the data also will show size of electric motor used. Never buy on basis of fan diameter or motor size alone; either can mislead you.

When comparing initial costs of any fans, be sure the units are comparable. Check air delivery rates (cubic feet per minute) at similar static pressures. Cost of operation should be compared in cubic feet per minute per watt or per 100 watts. Table 7 shows considerable variation in the cost of moving 30,000 cubic feet of air per minute, for ventilating a poultry building. Note that these fans are rated at 1/10-inch static pressure, for a direct capacity comparison.

Consider maintenance and service items such as totally enclosed motors, direct drive fans, noise factor, motor overload protection, low motor-starting current, and ease of maintaining and cleaning blades and shutters.

Variable speed fans are probably best for ventilating pullet houses because there is only a small amount of animal heat, and supplemental heat may be required. The gradual change in air movement removes the sudden shock of large intermittent air flows.

The high reliability and low maintenance of solid-state units are now proven. However, do not purchase an electronic speed controller for operating your present ventilating fans without checking with your ventilation system manufacturer. For example, it has been recommended that the speed control should be used only on direct-drive fans because belt slippage is likely at slow speed on belt-driven units.

Example: The tabulation below is based on a 6,000-layer operation. The annual net savings for such an operation due to proper fan selection could be as much as $435.50 per year, assuming that the producer purchased the type C instead of the type A fans.

Total cost per year fan A	$799.00
Total cost per year fan C	363.50
Total annual savings	$435.50

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual Savings	$435.50	$567.50	$699.50	$831.50

3/ A ventilation failure alarm may be advisable instead of automatic resetting overload devices.

Table 6--Cost of owning and operating fans at 30,000 ft³/min capacity 1/

Fan designation	Fan capacity at 1/10"	Fan efficiency factor	Fans needed	Total fan cost	Annual 2/ fixed cost	Estimated 3/ monthly operating cost	Total annual cost fixed and operating 1/
	ft³/min	ft³/min watt 1/10"	number	Dollars	Dollars	Dollars	Dollars
A	2,920	5.84	10	1,330	133.00	55.50	799.00
B	2,970	9.45	10	1,690	169.00	34.20	579.40
C	4,600	14.60	7	935	93.50	22.50	363.50
D	5,820	13.60	5	2,100	210.00	23.85	496.20
E	7,580	17.00	4	1,790	179.00	18.98	406.70

1/ 6,000 confined layers at 5 ft³/min per bird.

2/ Purchase price divided by 10 years with no interest charge, excluding wiring and thermostat control.

3/ Operating time estimated at 50 percent of total with electricity at 3¢ kWh.

Source: Adapted directly from (36).

EXAMPLE OF CUTTING COSTS THROUGH VENTILATION PRACTICES

$132.90 savings for a grower who produces 80,000 broilers per year

A computer model of a broiler operation developed by E.W. Walpole and N.E. Collins at the University of Delaware indicates that winter fuel consumption may be less when house temperatures are maintained at 70°-75°F. rather than at 65°. This is because of the decrease in the amount of ventilated air required to remove moisture from the house. The moisture-holding capability of air increases as air temperature increases, thus decreasing the amount of air required to remove the moisture. However, since the air must be heated to a higher temperature, the energy savings are difficult to measure. (The additional savings due to better feed conversion and improved bird environment are more important.) This sensitivity of the ventilation process prevents the development of a set of standard ventilation practices applicable to all poultry or to different regions of the country.

The example schedule in figure 8 may help establish a ventilation program. However, a local agricultural engineer can be helpful in developing a ventilation program specifically for a particular operation and area. Differences in outside relative humidity and evaporation rates may result in higher or lower ventilation requirements, particularly in the later weeks of production.

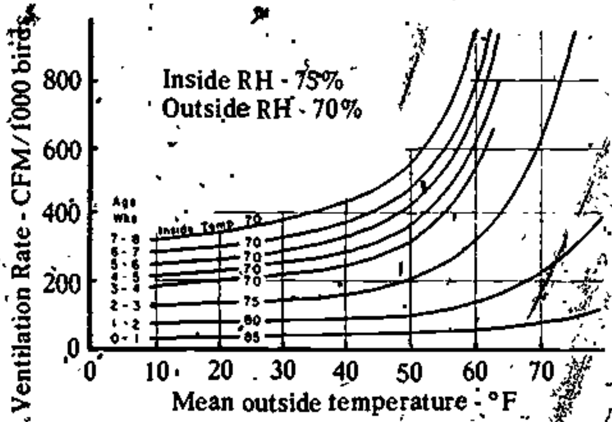


Figure 8. A FAMILY OF CURVES SHOWING THE VENTILATION REQUIREMENTS (CFM) FOR DIFFERENT AGE BIRDS AT A GIVEN INSIDE TEMPERATURE (T_i) AND AT VARIOUS OUTSIDE TEMPERATURES (T_0)

Example: A broiler producer has a 32 by 400 foot house which houses 16,000 birds per flock, and he raises 5 flocks per year starting in January, March, May, July, and September. Assume he uses warm room brooding with a temperature of 85°F. the first week, 80°F. the second, 75°F. the third, and 70°F. the remaining weeks and uses a ventilation schedule of 60 cubic feet per minute of air per 1,000 broilers the first week and increases 60 cubic feet per minute per 1,000 each additional week of age. Table 8 presents the estimated fuel savings attained from following the ventilation rates based on figure 8 for the January and March flocks. No significant savings were found for the remaining flocks. Propane is assumed to cost 30 cents a gallon.

Table 8--Estimated fuel savings for January and March flocks

Flock	Outside temperature (degrees F)	Estimated savings on LP gas (gallons)	Savings (dollars)
January	36	405	121.50
March	44	38	11.40
Total		443	$132.90

These estimates were made by subtracting the ventilation rate derived from figure 8 from the assumed ventilation rate for each week during the first 6 weeks of production. The difference in total air volume ventilated per week was then calculated as follows:

January flock, first week

60 ft^3/min/1,000 birds - 40 ft^3/min/1,000 = 20 ft^3/min/1,000 birds

20 ft^3/min/1,000 birds x 16,000 birds/flock x 60 min/hour x 24 hr/day x 7 days/week x 30 Btu*/lb of air - 14 ft^3/lb of air = 6,912,000 Btu/flock, 1st week

6,912,000 Btu/flock, 1st week ÷ 92,000 Btu/gal propane = 75 gal propane/flock, 1st week

*Estimated from psychrometric charts subtracting incoming air enthalpy from exhaust air enthalpy.

The above savings estimate is subject to debate because (1) there are differences of opinion among engineers on ventilation rates; (2) few if any growers actually know their ventilation rate since it is controlled by thermostats and/or varied manually; and (3) ventilation rates may vary by region, type of poultry, type of house, age of birds, etc. However, the example still serves as an illustration of the cost of over-ventilation.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual Savings	$110.75	$132.90	$155.05	$177.20

FEEDING, WATERING AND WASTE REMOVAL

Feeding, watering, waste removal, and other related practices account for 18 percent of the energy used in poultry production. Most of the energy used in these poultry operations is mechanical. Manure drying, if manure is dried for feed or fertilizer, is an exception.

There are potential dollar savings in reducing energy use by intermittent lighting, cutting down on the number of cycles per day for mechanical feeders, and eliminating wasted pumping of water and unnecessary evaporation.

Energy Tips

Keep mechanical feeders clean and adjusted at as low a level as feasible for adequate feeding.

Keep watering systems clean and adjusted. Spilled water requires considerable heat to evaporate and remove as well as energy to pump and distribute.

Save energy on a continuous-flow V-trough watering system by turning off water at night and operating on an intermittent system in the day.

Clean all electric motors periodically with pressurized air.

Limit the number of times automatic feeders are run per day to the minimum required to achieve the desired feed consumption.

Table 9--*Kilowatts required per hour of use for various electric motor sizes* 1/

Horsepower rating of motor	Kilowatt-hours
1/4	0.667
1/3	0.828
1/2	1.127
3/4	1.587
1	1.840
1-1/2	2.300
2	2.760
3	3.909
5	6.440
7-1/2	9.202
10	11.500

1/ The values are for single-phase AC motors running at speed usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current. If a specific motor is of concern, check the actual name-plate data. Theoretically, the kilowatts required per hour of use should be less than shown--approximately 1 horsepower per kilowatt-hour for most sizes. When the loads are uniformly applied to motors close to the optimum load for which the motor was designed, better efficiency can be expected than is shown in table 9.

Source: Adapted from (4) p. 53.

EXAMPLE OF CUTTING COSTS BY REDUCING THE NUMBER OF BROILER FEEDINGS AND USING INTERMITTENT LIGHTING

$239.60 savings for a grower who produces 70,000 broilers per year

Both intermittent lighting and reduced operation of a mechanical feeder save electricity. The reduction in lighting electricity is greater for environmentally controlled houses than for conventional houses since artificial light is presently required 24 hours per day in the former.

Example: A grower has one 40 by 280 foot environmentally controlled broiler house. He produces 5 flocks for a total of 70,000 broilers annually. The house is equipped with a chain-type mechanical feeder which has 1,000 feet of feeding trough. The feeder takes approximately 15 minutes for each cycle. It is equipped with one 3/4-horsepower electric motor. The grower presently cycles the feeder every 45 minutes (30 minutes off, 15 minutes on).

The house is lighted with 69 25-watt incandescent bulbs. Thus, the total present use per day is 41 kilowatt-hours. The mechanical feeder and lights are used the last 5 weeks of each production period.

Assume the grower adopts intermittent lighting with the feeder cycling every hour (45 minutes off, 15 minutes on). The total estimated electricity use for lights and for the mechanical feeder is calculated and presented in table 10. The net savings at 4 cents per kilowatt-hour also are shown.

Without Intermittent Lighting

Lights per flock - 69 bulbs x 25 watts/bulb ÷ 1,000 watt hours/kWh x 24 hours/day x 35 days/flock 1,449 kWh per flock.
1,449 kWh/flock x 5 flocks = 7,245 kWh

Feeder per flock 3/4 hp x 2.116 kWh/hp hour x 15 min/cycle ÷ 60 min/hours x 32 cycles/day x 35 days/flock = 444 kWh per flock

444 kWh/flock x 5 flocks = 2,220 kWh

With Intermittent Lighting

Lights per flock - 69 bulbs x 25 watts/bulb ÷ 1,000 watt hours x 15 min/cycle ÷ 60 min/hour x 24 cycles/day x 35 days/flock = 362 kWh per flock

362 kWh/flock x 5 flocks = 1,810 kWh

Feeder - 3/4 hp x 2.116 kWh/hp x 15 min/cycle ÷ 60 min/hour x 24 cycles/day x 35 days/flock = 333 kWh per flock

333 kWh/flock x 5 flocks = 1,665 kWh

Table 10--Estimated energy savings from using an intermittent lighting and feeding schedule

Schedule	kWh without intermittent lighting	kWh with intermittent lighting	kWh savings	Dollar savings
Lighting	7,245	1,810	5,435	$217.40
Feeder	2,220	1,665	555	22.20
Total	9,465	3,475	5,990	$239.60

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual Savings	$179.70	$239.60	$299.50	$359.40

EXAMPLE OF CUTTING COSTS BY REDUCING THE NUMBER OF MECHANICAL FEEDING CYCLES

$33.20 savings for a grower who produces 70,000 broilers per year

Energy can be saved by reducing the mechanical feeder cycles. Compare a feeding cycle of 45 minutes with one of 75 minutes:

Example: A grower has a 40 by 280 foot environmentally controlled broiler house. He produces 5 flocks for a total of 70,000 broilers annually. The house is equipped with a chain-type mechanical feeder 1,000 feet long. The feeder takes approximately 15 minutes for each cycle. It is equipped with one 3/4-horsepower electric motor. The grower presently cycles the feeder every 45 minutes.

The mechanical feeder is used the last 5 weeks of the production period. By reducing the mechanical feeder cycles to once every 75 minutes, an estimated net savings of $33.20 at 4 cents per kilowatt-hour can be achieved.

Feeder Cycles Every 45 Minutes

3/4 hp x 2.116 kWh/hp hour x 15 min ÷ 60 min/hour x 32 cycles/day x 35 days/flock = 444 kWh per flock

444 kWh/flock x 5 flocks = 2,220 kWh

Feeder Cycles Every 75 Minutes

3/4 hp x 2.116 kWh/hp hour x 15 min/cycle = 60 min/hour x 20 cycle/day x 35 days/flock = 278 kWh

278 kWh flock x 5 flocks = 1,390 kWh

Net Savings = 830 kWh

Net Dollar Savings = $33.20

Savings at Different Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual Savings	$24.90	$33.20	$41.50	$49.80

HOUSING DESIGN, CONSTRUCTION, AND MAINTENANCE

Housing design, construction, and maintenance have considerable effect on the energy used in poultry production, particularly during brooding. You can cut energy costs by properly designing new houses or modifying existing ones. For example, you can add insulation or install reflective covering on inside surfaces.

The insulation capabilities of materials vary widely, so select the most efficient construction or insulation materials. One measure of the relative insulation value of different materials is the R-value. The R-value of a material is a measure of its ability to resist heat flow. Table 11 presents the approximate 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 on the warm side of the insulation to prevent the moisture in the house 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 an hour when the pressure difference is one inch of mercury.)

Characteristics other than the heat resistance of insulating materials also should be considered. For example, sprayed-on polyurethane should seal small cracks and reduce infiltration of air; however, some poultry producers have experienced problems in maintaining polyurethane.

Energy Tips

Check insulation to make sure it is in place and dry.

Check the walls, side curtains, doors, windows and ceiling for leaks.

Contact your local or State extension engineer, or a consulting engineer, to determine the amount and kind of insulation recommended for housing in your area, as well as for general guidance on housing construction or modification.

EXAMPLE OF CUTTING COSTS BY INSULATING YOUR TURKEY BROODER HOUSE

$377.76 savings for the grower of 30,000 turkeys per year

In general, more insulation should be used in the ceiling (roof) than the walls to maximize return on expenditures for insulation.

Example: A turkey producer has two 40 by 200 foot turkey brooder houses. He produces 30,000 turkeys annually. He places 2 flocks in each brooder house per year (in March and May). Assume he has 3 1/2 inches of batt-type mineral wool installed between the rafters of each of his houses at a cost of 30 cents per square feet. The estimated fuel savings on each of his flocks with LP gas at 30 cents per gallon are shown in table 12. The estimated R-values before and after insulation are 1.81 and 14.76, respectively. The fuel savings are based on the first 4 weeks of fuel use with the average outside temperatures indicated in the table and an assumed inside temperature of 75°F.

Each house has 8,875 square feet of ceiling (roof) area. At 30 cents per square feet, it will cost $2,662.50 to insulate with 3 1/2 inches of batt-type mineral wool insulation. The total cost for both houses is $5,325. If he borrowed the $5,325 at 10 percent interest over 10 years, his annual payment would be $866.64. His total savings is $1,244.40. Thus, his estimated net savings per year for both houses would be $377.76. This example presents the most extreme case of no insulation in the roof versus a well insulated roof. The other insulation e[illegible]es in this section compare alternative levels of insulation.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual savings	$170.36	$377.76	$585.16	$792.56

Table 12--Estimated fuel savings from 3 1/2 inches of mineral wool insulation in the ceiling of both brooder houses

Month	Outside temperature (degrees F.)	LP gas savings (gallons)	Dollar savings
March	28	2,954	886.20
May	56	1,194	358.20
Total		4,148	$1,244.40

EXAMPLE OF CUTTING COSTS BY PROPERLY MAINTAINING A WATERING SYSTEM

$104.10 savings from eliminating spilled water at a rate of 10 gallons per day

Proper cleaning and adjustment of a watering system can save energy.

Fuel usage is increased to evaporate spilled moisture.

The resulting wet litter is also a bird health hazard and a source of ammonia gas. Additional ventilation is required to remove both the moisture and the resulting ammonia, thus increasing the ventilation heat loss.

Example: If a grower had water spillage from dripping waterers, sticking floats, etc. of only 10 gallons per day (equivalent to one dripping faucet), his annual loss would be considerable (3,650 gallons of water). Assuming this spillage occurred in a heated house, the cost of the spillage can be partially estimated by determining the cost of the fuel required to evaporate the moisture. However, this estimate is too high in the warmer months when supplemental heat is not required and may be too low in the winter months if additional ventilation is required to remove the moisture.

The estimated annual cost of evaporating the water spillage is calculated below. Assuming that water spillage can be avoided through proper adjustment of waterers, this cost can be considered an estimate of the potential savings from proper maintenance.

At 1,050 Btu/lb of water (approximate heat of evaporation) it would take 8,746.5 Btu to evaporate 1 gallon of water (8.33 pounds). Propane gas is used at a cost of 30 cents per gallon.

8,746.5 Btu/gal of water x 10 gal/day x 365 days/year = 31,924,725 Btu/year.

31,924,725 Btu/year ÷ 92,000 Btu/gal of propane = 347 gal of propane/year.

Total saving: 347 gal x $.30/gal = $104.10

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual Savings	$86.75	$104.10	$121.45	$138.80

Table 11--Insulation value of materials

Material	Resistance rating (R)
Air space, enclosed by ordinary materials	0.91
Air space, aluminum foil one side	2.17
Air space, aluminum foil both sides	2.44
Surface film, inside; nonreflective (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, light weight (8")	2.00
Concrete, regular (8")	0.64
Sheathing or flooring, softwood (3/4")	0.94
Sheathing or flooring, hardwood (3/4")	0.68
Drop siding, 1 x 8	0.79
Bevel siding, 1/2 x 8	0.81
Bevel siding, 3/4 x 10	1.05
Building paper	0.06
Roll roofing, asphalt	0.15
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
Rolled side wall curtain	Negligible

Source: See (15). Compiled from (49) and (52).

EXAMPLE OF CUTTING COSTS BY ADDING INSULATION TO YOUR BROILER HOUSE

$381.60 savings for a grower who produces 90,000 broilers per year

Adding insulation to a poultry house which already has insulation can save money and energy. In general, more insulation should be used in the ceiling than walls. Adding insulation only to the ceiling of an existing conventional side curtain house saves energy and money.

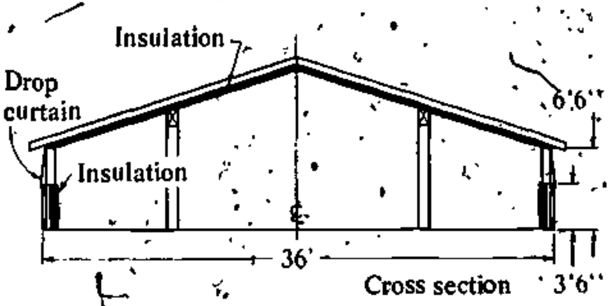


Figure 9. DIAGRAM OF INSULATED BROILER HOUSE WITH SIDE CURTAINS

Example: A broiler grower has two 36 by 200 foot broiler houses. He produces 90,000 broilers annually. Assume the house presently has one-half inch of insulation board between the rafters. Assume he installs an additional 2 inches of polystyrene at a cost of 30 cents per square foot. The total R-value will increase from 2.1 to 10.1. His estimated fuel savings on each of his 5 flocks per year are shown in the table based on LP gas at 30 cents per gallon. The fuel savings are based on the first 4 weeks of fuel use for each flock with the average outside temperature indicated in table 13 and an assumed inside temperature of 75°F.

Table 13--Estimated fuel savings from 2 inches of polystyrene insulation on the ceiling of both broiler houses

Month	Outside temperature (degrees F.)	LP gas savings (gallons)	Dollar savings
January	36	1,718	515.40
March	44	1,366	409.80
May	63	528	158.40
July	76	0	0.00
September	69	264	79.20
Total		3,876	$1,162.80

Each house has 8,000 square feet of ceiling area, thus the cost for installing the additional 2 inches of polystyrene in each house is $2,400 for a total cost of $4,800. If he borrowed the $4,800 at 10 percent interest over 10 years, his annual payment would be $781.20. His fuel saving is $1,162.80 a year. Thus, his estimated net savings per year for both houses would be $381.60.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual savings	$187.80	$381.60	$575.40	$769.20

EXAMPLE OF CUTTING COSTS BY ADDING INSULATION

$68.33 savings for a grower who produces 90,000 broilers per year

The appropriate amount of insulation for a poultry house depends on how long the owner will be raising poultry, because insulation is an investment which can pay for itself over time.

The owner should first contact a building materials supplier and a contractor to determine how much it will cost to install insulation with total R-values of 6 to 12. The R-value range may be higher or lower depending on the region. Then a local extension engineer can offer advice on the type of insulation to install and on how it should be installed. He should also be able to help determine the potential fuel savings for each R-value. Since these savings vary regionally, the break even R-value point between cost of insulation and fuel saving will vary regionally.

Figure 10 may help to evaluate alternatives. The figure starts at an R-value of 0.78 which is close to zero insulation. The total fuel savings, which are shown in gallons per week per 10,000 square feet of area insulated per degree difference between inside and outside temperature, are only applicable to the first 4 weeks of production or less since the birds begin supplying a larger portion of the total heat required in the latter weeks:

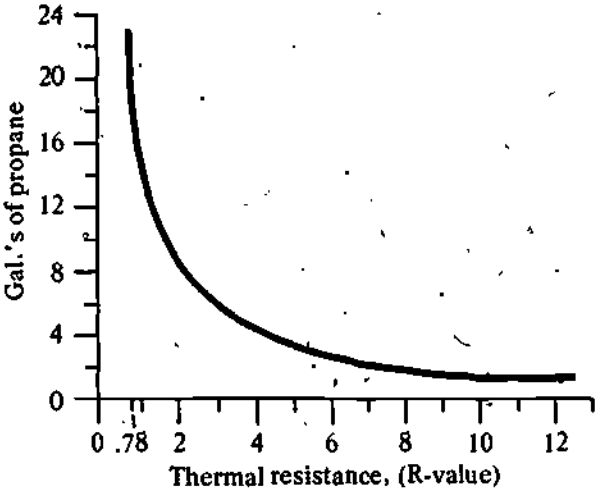


Figure 10. GALLONS OF PROPANE REQUIRED PER WEEK TO COMPENSATE FOR THE B.T.U. HEAT LOSS PER 10,000 SQ. FT. OF EXPOSED ROOF OR WALL AREA PER 1°F. DIFFERENCE BETWEEN INSIDE AND OUTSIDE TEMPERATURE.

Example: A broiler grower has two 36 by 200 foot broiler houses. He produces 5 flocks of 18,000 birds per year for a total of 90,000. The grower desires to limit the addition of insulation to that which could be paid for in 5 years at 10 percent interest. Assume that the first inch of polystyrene costs 18 cents per square feet installed and that each additional inch of polystyrene costs 12 cents per square feet. The installation charge is assumed to stay constant per square feet. The savings in gallons of propane per 10,000 square feet of area per week per degree difference in inside and outside temperature are taken from the figure.

Assume that insulation is added only to the ceilings (roof) and that the houses had a half inch of insulation board initially (2.1 R-value). The total area to be insulated is 16,000 square feet (8,000 ft^2 per house). Finally, assume that his flocks are usually placed in January, March, May, July, and September when the average outside temperatures are 36°F., 44°F., 63°F., 76°F., and 69°F., respectively, and that the inside temperature is 75°F.

A sample calculation is shown below. Table 14 presents a comparison of annual cost and annual energy savings with propane priced at 30 cents per gallon.

Total annual inside-outside temperature difference (no savings in July) = (75°-36°) + (75°-44°) + (75°-63°) + (75°-69°) = 88°F.

Annual gallons of propane required to compensate for heat loss through roofs of both houses with R-values of 2.1: 88°F. difference per year x 8.7 gal propane/10,000 $ft.^2$/1°F difference/week x 4 weeks x 16,000 $ft.^2$ = 4,900 gal. propane

Annual dollar loss = 4,899.8 gal of propane x \$.30/gal propane = \$1,469.94

Annual dollar cost for 1" of polystyrene insulation = 16,000 ft^2 x \$.18/ft^2 of insulation x 0.2638 (annuity factor for a 5 yr 10% loan) = \$759.74 per year.

In this case, the grower would select 1.5 inches of additional polystyrene insulation and save \$68.33 cents per year for the first 5 years when recovering the installation cost and over \$1,000 per year minus insulation maintenance costs, if any, after the initial 5 years. However, if the grower were to consider the potential for fuel cost increase, he may add even more insulation. For example, 40-cent propane would show a savings of \$1,622 with 2.5 inches of additional polystyrene. Thus this alternative becomes economically feasible.

Table 14--Estimated costs and savings for alternative levels of insulation

Inches of polystyrene	R-value	Gallons of propane lost per year	Annual gallons of propane conserved by adding insulation	Annual dollar savings from adding insulation	Annual dollar costs for added insulation
0	2.1	4,889.8			
1.0	6.1	1,689.6	3,210.2	963.06	759.74
1.5	8.1	1,295.4	3,604.4	1,081.32	1,012.99
2.0	10.1	1,013.8	3,886.0	1,165.80	1,266.24
2.5	12.1	844.8	4,055.0	1,216.50	1,519.49

EXAMPLE OF CUTTING COSTS BY SEALING CRACKS AROUND POULTRY HOUSE DOORS AND WINDOWS OR SIDE CURTAINS

$55.80 savings for a grower who produces 77,000 broilers per year

Air infiltrates at the rate of 220 cubic feet per hour per foot of crack for a poorly fitted door with a wind velocity of 15 miles per hour. A poorly fitted double-hung wood window is one which has a 3/32-inch crack and clearance, and a poorly fitted door is one which permits twice the infiltration rate as a poorly fitted double-hung wood window. Curtains, windows, and doors in a broiler house could fall into the poorly fitted door category. 5/

Example: A broiler grower has a 40 by 308 foot broiler house and produces 77,000 broilers per year. Assume he maintains an inside temperature of 85°F. the first week, 80°F. the second, 75°F. the third and 70°F. the remainder of the 8-week growing period. His outside temperature for each of 5 flocks placed in January, March, May, July and September are as shown in table 15. There is a 15-miles-per-hour wind an average of 8 hours per day. Finally, assume he desires to ventilate at a rate of 60 cubic feet per minute per 1,000 broilers the first week of production and increase by 60 cubic feet per minute each week thereafter.

The estimated rate of infiltration is equal to the total of all the perimeters of the door and side curtains divided by 2 and multiplied by infiltration rate of 220 cubic feet per hour per foot of crack. The total of the perimeters is divided by 2 since the air is assumed to enter through half the cracks and exhaust through the other half. For this house feet: (308 ft x 4) + (3 ft x 4) (lengths and heights of the side curtains) + (4 x 27 ft) (end doors). Thus the total infiltration is 148,720 cubic feet per hour.

The fuel savings in the table are based on the assumption that the infiltrated air substitutes for the required ventilated air. Therefore, only the cubic feet of air in excess of the required ventilation is considered in estimating heat loss. This assumption does not imply that infiltration is a good substitute for proper ventilation.

5/ Adapted directly from (15).

Table 15--Estimated fuel savings from properly sealing doors and windows

Month	Outside temp. (degrees F.)	LP gas savings (gallons)	Dollar savings 1/
January	36	68	$20.40
March	44	57	17.10
May	63	29	8.70
July	76	11	3.30
September	69	21	6.30
Total		186	$55.80

1/ Assuming LP gas costs 30 cents per gallon.

Savings at Different LP Gas Prices

Cents/gal	25¢	30¢	35¢	40¢
Annual Savings	$46.50	$55.80	$65.10	$74.40

KEEPING RECORDS OF ENERGY USE

We have stressed the importance of energy conservation for the poultry industry and have presented a number of energy conservation measures to save money. The following Energy Use Recorder and Energy Diary charts may help determine how much energy is used in a particular operation and identify when and where it is used.

The recorder is designed to help record changes in bird numbers during the month--the energy usage is related to birds on hand. It allows recording the energy use by type of energy. The diary permits the user to record fuel and electricity prices and make notes concerning special factors which may have affected energy use or production that month such as weather and disease.

Read electric, gas (propane or natural gas) and gasoline or diesel fuel meters monthly. In the absence of meters, record amounts purchased on fuel bills. Although these may not be on a monthly basis, they should still provide a basis for estimating monthly and annual energy use. Gasoline or diesel fuel use also could be recorded as it is used in vehicles, tractors, or engines. This data already may have been recorded for gasoline tax refund claims.

Energy Use Recorder

Year ____ Type of Poultry ____

Date	Number on hand	Mortality since previous entry	Number added or started	Number sold	Date	Electricity (kilowatt hours)	Gasoline or diesel (gallons)	[1] ( )	[1] ( )
Jan.									
Feb.									
Mar.									
Apr.									
May									
June									

See footnotes at end of chart.

Energy Use Recorder

Date	Number on hand	Mortality since previous entry	Number added or started	Number sold	Date	Electricity (kilowatt hours)	Gasoline or diesel (gallons)	1/ ( )	1/ ( )
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									

1/ Use this column for fuel oil, natural gas, propane, coal, or other fuels.

Energy Diary

Year _____ Type of poultry _____

							Notes
Jan.	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	
Feb.	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	
Mar.	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	
April	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	
May	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	
June	Prices paid for:					¢/gal	
	Electricity	_____	¢/kWh	LP gas		_____	
	Natural gas	_____	ft³*	Gasoline/diesel		_____	
	Coal	_____	$/ton	Fuel oil		_____	

* Or therms.

Energy Diary

Year ____ Type of poultry ____

						Notes
July	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline/diesel	____	
	Coal	____ $/ton		Fuel oil	____	
Aug.	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline/diesel	____	
	Coal	____ $/ton		Fuel oil	____	
Sept.	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline/diesel	____	
	Coal	____ $/ton		Fuel oil	____	
Oct.	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline/diesel	____	
	Coal	____ $/ton		Fuel oil	____	
Nov.	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline/diesel	____	
	Coal	____ $/ton		Fuel oil	____	
Dec.	Prices paid for:				¢/gal	
	Electricity	____ ¢/kWh		LP gas	____	
	Natural gas	____ ft^3*		Gasoline	____	
	Coal	____ $/ton		Fuel oil	____	

* Or therms.

In the absence of a separate electric meter for the poultry operation, an owner may be able to estimate the annual number of kilowatt-hours used in his home by using the estimated appliance kilowatt-hour usage rates in table 16. Divide the estimated annual household electricity usage by 12 to get a monthly estimate. This value can be entered in the energy record and subtracted from the total electricity use to estimate poultry electricity use each month.

Another way to figure electricial use for the poultry operation is to use the energy estimator schedules which follow. Energy use estimator worksheet 1 is a schedule of the hours of use for various electric motors and electric lights on the farm. Energy use estimator worksheet 2 is a chart to assist in estimating the kilowatt-hours used in the poultry operation. Conversion factors used in the second column can be obtained from table 9 on page 44.

Table 16--Estimated annual energy requirements of electric household appliances 1/

	Est. kWh 1/ consumed annually
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 1/ consumed annually
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 considered.

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, N.Y. 10016.

Energy Use Estimator--Worksheet 1

Type of equipment	Average number of hours by month for various equipment operations daily												
	J	F	M	A	M	J	J	A	S	O	N	D	Total
Mechanical feeder													
Feed auger													
Automatic waterer													
Egg collector													
Manure removal equipment													
Water pump													
Ventilation fans													
Lighting													

Energy Use Estimator--Worksheet 2

Electricity used during the month of _____ 19__

Type of Equipment	(1) No. of each	(2) Kilowatts per hour of use	(3) Hours of use	(4) Kilowatt-hours
Mechanical feeder				
Feed auger				
Automatic waterer				
Egg collector				
Manure removal equipment				
Water pump				
Ventilation fans				
Lighting 1/				
Total				

1/ Enter watts per bulb times 0.001 in column 2.

Procedure for completing Energy Use Estimator Worksheet 2:

1. Enter the number of each type of equipment in column 1.

2. Select the correct kilowatt-hours of use conversion factor for that size of motor and enter it in column 2. See kWh conversion factors on page

3. Enter hours of use from Energy Use Estimator Worksheet 1 in column 3.

4. Multiply columns 1, 2, and 3 together and enter the result in column 4 (kWh per month).

5. Add totals in column 4 for the estimated monthly electrical usage for the poultry operation.

BTU ACCOUNTING

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

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

Btu Conversion Factors

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

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

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